building a better pest

Scientists want to genetically engineer the bite out of insects. Will Mother Nature bite back?

By Trevor Thieme

TACNA IS A FLYSPECK OF A TOWN LOCATED ALONG A desolate stretch of Interstate 8 in Arizona. There are few amenities—the town has one restaurant, a single hotel, and a gas station. But every year a handful of cotton farmers gather here to swap ideas about their crop. Conversation revolves around planting strategies, pesticides, and new strains of seeds.

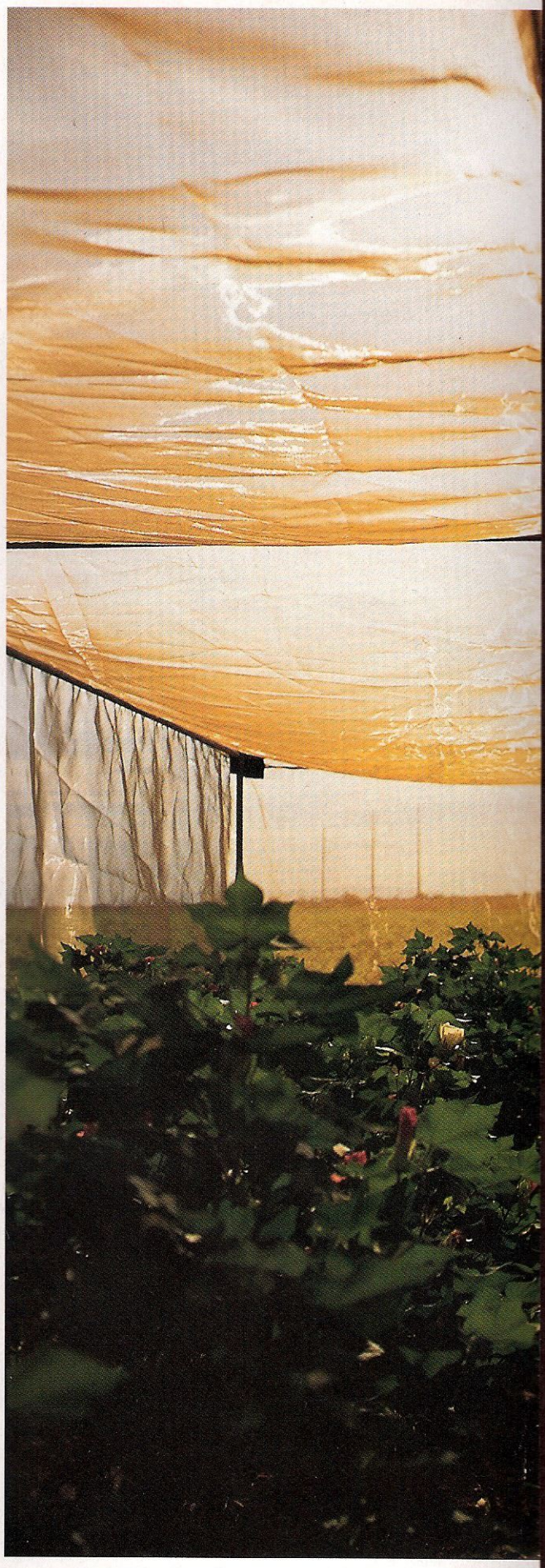
This year, however, all eyes turn to a newcomer: Robert Staten.

Dressed in khakis, a white-collared shirt and oxford shoes, Staten stands out in this crowd of straw hats and glimmering belt buckles. But Staten's attire is not what grabs the farmers' attention; it's the controversial new topic he brings to the table: using the tools of molecular biology to wipe out an insect that's threatening their livelihood.

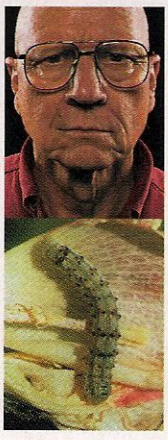
For the past seven years Staten, who heads the technical support laboratory at the Animal and Plant Health Inspection Service in Phoenix, a division of the U.S. Department of Agriculture, and colleagues at the University of California, Riverside, have been tinkering with the DNA of one of the cotton industry's most voracious nemeses: the pink bollworm moth—a pesky insect about the size of a lemon seed that's devastating cotton crops throughout the Southwest. Their goal is to create moths with a lethal genetic flaw that effectively renders them infertile. Once unleashed in cotton fields, the engineered moths would mate with the wild population; over time, the species would die out.

The hope is to eradicate a pest that infests nearly 500,000 acres of prime cotton. California's Imperial Valley, for example, was once home to more than 100,000 acres of cotton but the bollworm chewed its way through most of it, shrinking the plantable area to a mere 5,000 acres in less than 10 years.

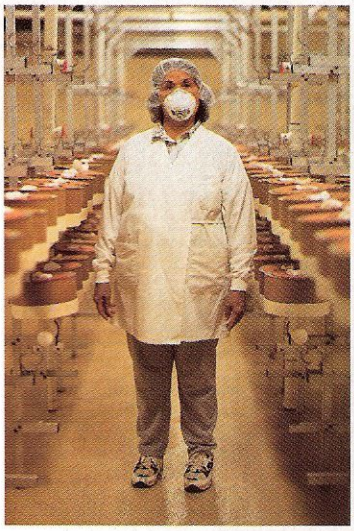
PHOTOGRAPHY **BRENT HUMPHREYS**

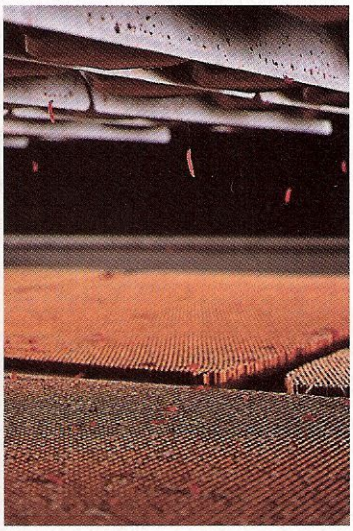


BUG MAN
Robert Staten (below), a scientist at the U.S. Department of Agriculture, hopes to be the first to conduct a field trial of a genetically modified insect, the pink bollworm (bottom). Inside the release tent (right); a bollworm trap (far right).




INSECT TRAP
GOVERNMENT PROPERTY
PLEASE DO NOT DISTURB
For information contact your County or State or Federal
Plant Protection Programs Office
State
County
Trap No.
Catch Date





THE INSECTARY
At an insect lab just outside of Phoenix, scientists study the lifecycle of the pink bollworm moth in an effort to control its population. Clockwise from right: egg-laying room; larvae exiting rearing container to pupate below; release tent in a cotton field; larvae room.

"I have literally walked through cotton fields completely wiped out by pink bollworm," says Wallace Shropshire, chairman of the California Cotton Pest Control Board and a 49-year veteran of the cotton industry. "You would need an arsenal to control these tiny beasts. I see genetically modified pinkies as our silver lining."

Humans have managed to subdue much of the natural world, but bugs have mostly eluded us. Advances in genetics over the past few years, though, could ultimately help us gain the advantage. While the debate over the merits of genetically modified foods is still raging, scientists are already beginning to apply the same techniques to insects. Staten's project is just one example. Biologists in Europe are genetically modifying mosquitoes so they can't transmit malaria. Similarly, at the Centers for Disease Control in Atlanta, researchers are tinkering with a beetle that carries Chagas disease—a potentially fatal tropical illness. But although the potential benefits are great, the drawbacks, many environmentalists warn, could be disastrous.

The USDA isn't taking those risks lightly. Before unleashing genetically sterile moths, Staten will conduct a test run on moths that have been altered less radically. Instead of carrying a terminator gene, these moths will possess a harmless tracking gene. Later this year, Staten hopes to release some 2,300 of these moths in an enclosed tent propped in a cotton field to study their behavior.

Staten is a bit of an entomological Ahab. He's been locked in battle with the pink bollworm since 1970, when he was hired fresh out of graduate school by the USDA to help eradicate the invasive insect in southern California. "Pinkie was this brand-new pest that was just blowing through the Southwest," remembers Staten. "I felt like I was on a tricycle trying to catch up with a freight train."

Pesticides, the most obvious remedy, don't work very well because of the bug's cryptic lifecycle. Pink bollworms spend the majority of their lives hidden. The larvae nestle deep inside cotton bolls—fluffy capsules of seeds—or hide in cracks in the soil. The insects spend only about a week of their lives as adult moths and emerge solely at night.

Another way to shrink moth populations is to sterilize some of the males with blasts of radiation. But the technique damages the males so much that they can scarcely compete for females in the wild. "As anyone who's gone through chemotherapy knows," says Staten, "radiation debilitates."

Scientists have also tried a more indirect method: engineering cotton plants to produce their own insecticide and kill the insects that feast on them. But fearing that bugs might grow resistant to the plant-made insecticide, officials have restricted use of the modified cotton.

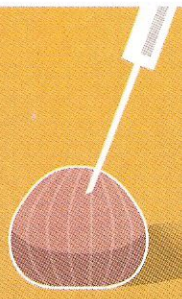
About 10 years ago Staten stumbled across another option. Over a dinner conversation, he learned that one of his colleagues had successfully swapped a set of genes from one species of fruit fly to another. Might he be able to take a desirable gene from a fruit fly and transfer it into the pink bollworm? Staten enlisted the help of Tom Miller, a professor of entomology at the University of California, Riverside, and set to work.

The most attractive option was to give the moths a terminator gene that renders their eggs incapable of maturing—a gene developed by Oxford University geneticist Luke Alphey. But first the team had to figure out a way to get the

JOHN GRIMWADE (2)

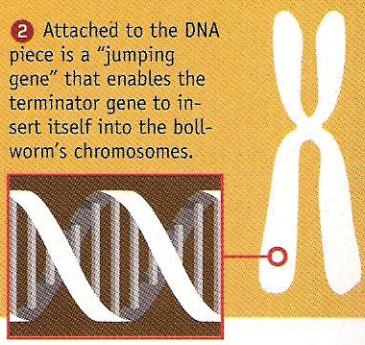
Pest Management

Scientists are trying to engineer the pink bollworm to stop it from chewing up the country's cotton crop. Here's how it's done.



1 Technicians inject a freshly laid, hour-old bollworm egg with a piece of DNA. The DNA contains a terminator gene that disrupts egg development.

2 Attached to the DNA piece is a "jumping gene" that enables the terminator gene to insert itself into the bollworm's chromosomes.



gene into the bug. They decided to piggyback it on a piece of DNA called a transposable element, or jumping gene, a gene sequence that has the peculiar ability to insert itself into chromosomes. They would then inject moth eggs with the jumping gene carrying the terminator DNA and pray that the construct "jumped" into the bollworm's DNA.

But there was a catch. Since the terminator gene prevents eggs from developing, how would Staten and Miller be able to grow the genetically modified moths in the lab? What they needed was to give the terminator gene an off switch.

Alphey, it turns out, has developed a way to use a particular gene's response to the common antibiotic tetracycline as an on/off switch. Once that gene is attached to the terminator gene, Staten and Miller could silence the terminator gene at will simply by feeding the moths a little tetracycline.

While Miller tinkers with the moths in the lab, Staten is busy preparing for a field trial. He spent much of this past summer in a nondescript cotton field just outside of Phoenix. One hot afternoon, Staten watches closely while a colleague peels apart the Velcro door of a translucent mesh tent and empties bowls of moths into the enclosure. The insects settle into the nooks of the tent, waiting for the sun to set.

This is a test run for the test run. These insects are sterile, but they've been neutered in the traditional way. They've been nuked. Before Staten attempts a field trial with engineered moths, he's practicing his skills with these moths to make sure he's got the recapture procedure down. "We have to make sure we know what the hell we are doing," he jokes. "This will set the groundwork for how things are handled in the future."

The future, however, is exactly what concerns environmentalists. Knocking the pink bollworm out of the food web could throw the local ecosystem out of whack. And given the novelty of transgenic insects, they fear that federal and state governments lack the know-how to monitor these programs.

Staten counters that the pink bollworm is not native to the United States and so wiping it out shouldn't disrupt the existing ecosystem. The bats and other predators that feed on the bollworm are generalists, and there are plenty of other insects to go around.

A more serious threat, however, is the possibility of the jumping gene having enough gumption to leap all the way into another species—exterminating it as well. Critics point out that genes from genetically engineered corn have already jumped into conventional crops, and they fear that a similar hop might happen between the bollworm and another insect.

Alphey counters that even if such a transfer happened, the trait would not spread. Since the gene disrupts egg development, any organism that received the gene wouldn't be able to procreate.

But laboratory results don't always translate in the field. No one knows this better than Marjorie Hoy, a University of Florida entomologist. Several years ago, Hoy conducted a trial of a genetically modified mite. In the lab, she found that the added gene functioned normally for almost 200 generations. But once the mite was tested in the field, the gene stopped working.

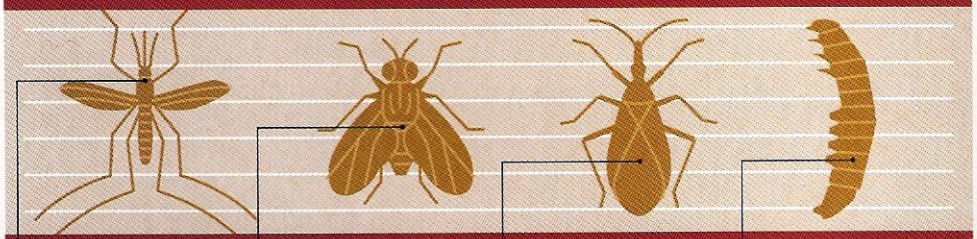
"It is a political decision of how much risk you want to tolerate," says Doreen Stabinsky, science advisor to Greenpeace's genetic engineering campaign. "It's one thing to put genetically modified cows in the environment; it is another to release genetically engineered insects that cannot be controlled or recalled."

Back in Tacna, Staten has clearly grabbed the growers' attention. Some scratch their heads, others stroke their beards. "Are you sure you can do this?" one asks with hope and apprehension.

"This is a high-payoff, high-risk venture," he responds, "and we're slowly going at it one day at a time. But in the long run, there is great potential to do a lot of good for society as a whole." ■

The Usual Suspects

By genetically engineering insects, scientists are attempting to "reform" them in various ways. Here's a sampling:



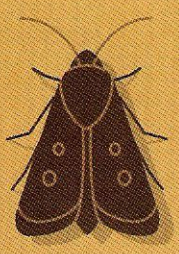
SUSPECT Mosquito
CRIME Transmits malaria
DEFENSE Create resistant strains or strains that don't feed on humans

SUSPECT Kissing bug
CRIME Spreads Chagas disease
DEFENSE Engineer to kill the parasite inside its gut that causes the disease

SUSPECT Medfly
CRIME Agricultural pest
DEFENSE Give bugs a temperature-sensitive gene that kills them in cold weather

SUSPECT Silkworm
CRIME None
DEFENSE Splice in genes that produce pharmaceuticals such as growth hormone and interferon

3 The eggs mature into adult moths. If the terminator gene has inserted itself into the genes that make the moth's sperm or eggs, the moths will be infertile: Females will lay plenty of eggs, but the eggs won't develop.



4 No more bollworm.