ILLUSTRATION COURTESY/BOEING, INC.

GLOBE STAFF PHOTO/JIM POWERS

Peter Glaser, inventor of the solar power satellite concept.

oping the heat-shield material, the big problem was how to generate the incredibly high temperatures needed to simulate the re-entry process. Glaser hit on the idea of using mirrors to concentrate sunlight, and was able to perform the necessary tests with a surplus searchlight mirror.

It was the combination of his work with solar energy and on developing space vehicles, Glaser said, that quickly led him to the mental leap of combining the two – harnessing the almost limitless supply of sunlight in space by using a fleet of huge satellites.

The big problem with Earth-bound solar power, Glaser explained in an interview, is that it is "a one-shift operation" – the sunlight is available only part of the day. He wanted a way to make solar power a "three-shift" operation, suitable for dependable "baseload" electric power generation.

SOLAR, Page 30

Boston Globe 8/19/91

GENETIC ENGINEERING

Biotech firm removes "rotting" gene from tomato

Seeks OK to market first genetically-altered food

By Simson Garfinkel
SPECIAL TO THE GLOBE

Last week, a Northern California company asked the US Food and Drug Administration for permission to bring to American supermarkets for the first time a genetically altered food: a tomato that doesn't rot on the way to market.

If the FDA approves, Calgene, Inc., an 11-year-old biotech startup firm, could have its tomatoes on store shelves by the fall of 1993, says Roger Salquist, chief executive officer, and "ultimately, there will be about 10" varieties around the country.

The new tomato is like a normal tomato, except for one small but significant change: Through recombinant DNA technology, the gene that triggers the rotting process has been cut out, turned around and reinserted into the plant's genetic code.

Firmer, heartier tomatoes are expected to be only the first in a wide-ranging harvest of genetically engineered plants. Products under development read like an organic farmer's wish list: carrots that taste sweeter; cotton that insects don't eat; vegetables and grains immune to viruses – and much more. With DNA technology, researchers also envision eventually creating plants that are resistant to drought, salt, cold, or even able to make their own fertilizer from the nitrogen in the air. According to a recent survey, at least 25 US companies are applying recombinant DNA technology to plants.

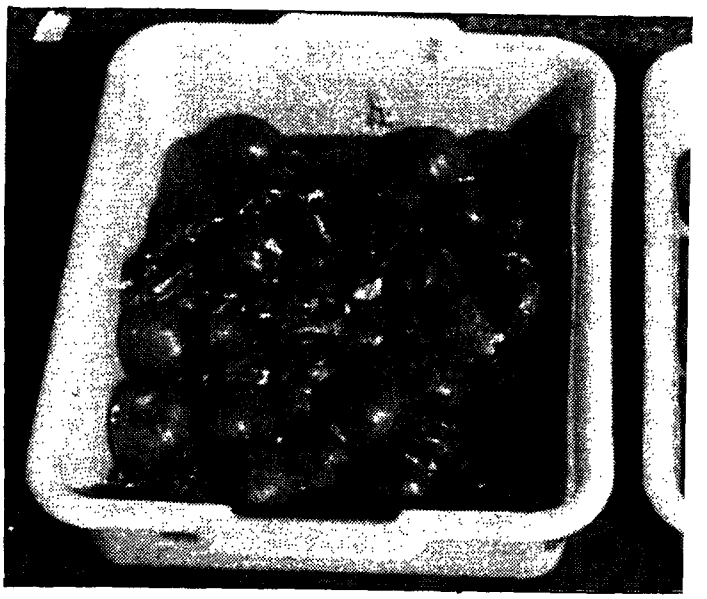
Even as products are being readied to leave the testing fields, however, questions remain about widespread use of the technology and how – or even if – consumers should be told their food is genetically altered. For some scientists, a major worry is that viruses and bugs resistant to organic pesticides may soon evolve in reponse to the manmade plants.

The Calgene tomato is likely to be consumers' first taste of the technology; the developer says the genetic change it made is so minor it expects no problem in getting FDA approval.

In normal tomatoes, a protein called polygalacturonase (PG) works like a kind of genetic self-destruct. Before the tomatoes are even ripe, PG is hard at work, literally digesting the fruit from the inside. In nature, its purpose is to help the tomato get its seeds into the ground quickly. But for farmers and grocers, PG

TOMATO, Page 30

The 'rotting' gene is sliced from tomato



Twenty-five days after harvest: Normal tomatoes at left are

■ **TOMATO**

Continued from Page 29

is a headache, responsible for countless tomatoes that are too soft to sell.

In the Calgene tomato, patented in 1989, the reversed gene causes the plant to produce substantially less PG, thus dramatically slowing the rotting process.

Normal tomatoes are picked green, refrigerated, and ripen on the way to market; the genetically engineered fruit can ripen on the vine and move to market without refrigeration. Daniel Wagster, Calgene's chief financial officer, says the new tomato looks, smells and tastes better than most store-bought ones.

In contrast to 10 years ago, few scientists now believe that, like a 1950s B-grade horror movie, a lone genetics experiment will produce a "super pest" that wreaks havoc on an unsuspecting ecosystem. "Some of the forecasts of disasters for biotech-organisms were wholly unrealistic," says Dr. Rebecca Goldburg, a scientist with the Environmental Defense Fund.

But there are still a few dark corners in the genetically-engineered fields of the not-to-distant future, dangers not of something going wrong, but of things going exactly as planned.

"The environmental community has been very concerned with how biotechnology is being applied – a large percentage of the technolgoy has been devoted to herbicide-tolerant plants," says Goldburg. She says 31 percent of the permits granted for field-testing this spring were for plants with herbicide resistance.

Ecologists say herbicide-tolerant plants will encourage the use of more herbicide. The industry says the opposite is true.

"Our whole premise in developing [these] plants...is that fewer chemicals are going to be in the environment to deal with weeds," says Jim Altemus, a spokesman for Monsanto, which makes the herbicide Round-Up.

Farmers use herbicides with "the anticipation that weeds are going to be there," says Altemus. A herbicide-resistant crop allows them to hold off until weeds become a problem; if weeds don't appear, no herbicide need be used.

Herbicide tolerance also fits in with the long-term plans of agribusiness. Five of the world's largest pesticide makers are using biotechnology to develop herbicide-resistant plants.

Industry's goal is to profit by selling patented seeds that work only with specific, patented pesticides. Monsanto, for instance, is developing a version of canola (used in Puritan Oil) that is tolerant to Round-Up.

Some ecologists, including Goldburg, have doubts about industry's stated motives. "Are chemical companies going to develop herbicide-tolerant plants so they can sell fewer chemicals?" asks Goldburg.

Some firms, among them Monsanto, say they do expect to sell fewer chemicals with their insect-resistant products. Last summer, Monsanto conducted six trials of its insect-resistant cotton around the country. In all cases, the cotton fared as well as cotton protected by conventional pesticides and much better than unprotected plants, says Dr. David Fischoff, director of Monsanto's plant molecular biology division.

The protective gene was based on a gene from the bacteria *Bacillus thuringiensis* (B.t.), which is commonly used by organic farmers as an alternative to synthetic chemical pesticides. The B.t. bacteria produces a powerful toxin that, although harmless to humans, dissolves an insect's gut on contact.

Farmers spray B.t. directly on their crops, but Fischoff's group has developed ways to insert the B.t. genes responsible for producing the toxin directly into plants such as cotton and tomatoes. The result is a plant that produces the toxin in every root, leaf, stem and fruit.

"The insects stop feeding almost immediately. They don't have to feed much to get a dose that will deter them and kill them," he says. "After half a decade of lab work ... we might have something that can ... be a potential plant product."

Other scientists familiar with the insect-resistant plants are not quite as optimistic.

"As soon as you put a B.t. gene into a plant, you are selecting for an insect population that is resistant to B.t.," says James Liebman, a plant pathologist at the University of California at Berkeley. That has happened with virtually every synthetic pesticide, starting with DDT.

In fact, Fischoff reported at a science conference earlier this year, B.t.-resistant insects have already been discovered. Monsanto says it will eventually deal with the resistance problem by using several toxins, or by developing a way to limit the toxin production to certain parts of the plant or to certain times of the growing season.

Work is also proceeding on plants that are virus-resistant. Strains of tomatoes, potatos, cucumbers and alfalfa have been developed. It's important work, because there's no chemical way to protect plants from viruses, often called "blight," or to cure infected plants.

A virus consists of two parts: an inner core made up of genetic material, either DNA or RNA, and an outer shell, called a "coat," made out of protein. To make a plant resistant to a particular virus, scientists isolate the DNA inside the virus that makes the coat and splice it into the plant's genetic code. For reasons not completely understood, if a plant is already producing the protein for a coat, the virus can't infect the plant.

Concern about hybrid forms

But some scientists are also beginning to worry about virus resistance, too. In a recent article in the Journal of Phytopathology, Dr. Gus de Zoeten of Michigan State University's department of Botany and Plant Pathology, suggested that a plant rendered genetically immune to one kind of virus could be infected by another kind; inside the plant, the genes for the two viruses could mix, forming a hybrid virus.

"The question is, are we creating new viruses by putting ... uses into plants, and can ... of viruses interact with ... uses?" de Zoeten says.

The biggest danger ... plants probably hasn't ... thought of, says Steven ... dent of the San Fran... Center for Scientific ... and the author of three ... of biotechnology. He ... technology that should ... cautiously. "If you look ... technology, the risks th... ably come back to haun... ones] nobody knows rig...

Trying to understan... ing world of biotechnol... eyes trained to look at ... ticides doesn't work. Ge... gineered plants have ... unique dangers to matc... fits, dangers that have ... covered, he says.

From the public's pc... crucial question is labe... foods containing genetic... lated ingredients be sp... ed? The FDA hasn't de...

"Under the Food, D... metic Act, the FDA is ... label all facts about fc... deemed significant by ... says Douglas Hopkins, ... torney with the Envirc... fense Fund. "We belie... variety of reasons, co... conclude that the fact t... neered food is material...

"We're looking a... foods should be inter... the act," says Dr. Jam... biotechnology coordi... FDA's Center for Foo... Applied Nutrition, w... predict when the FDA ... the Calgene request. ... anticipate that we wou...

omato

g-term plans of agribusi-
the world's largest pes-
rs a sing biotechnol-
elop bicide-resistant

's goal is to profit by
nted seeds that work
pecific, patented pesti-
nto, for instance, is de-
ersion of canola (used in
l) that is tolerant to

logists, including Goldl-
doubts about industry's
es. "Are chemical com-
to develop herbicide-
ts so they can sell fewer
sks Goldburg.
ms, among them Mon-
ey do expect to sell few-
with their insect-resis-
s. Last summer, Mon-
ted six trials of its in-
nt cotton around the
all cases, the cotton
as cotton protected by
pesticides and much
nprotected plants, says
schoff, director of Mon-
molecular biology divi-

ectiv ne was based
m the bacteria *Bacillus*
(B.t.), which is com-
y organic farmers as an
o synthetic chemical
he B.t. bacteria pro-
ful toxin that, although
umans, dissolves an in-
contact.
spray B.t. directly on
ut Fischoff's group has
ys to insert the B.t.
sible for producing the
into plants such as cot-
ntoes. The result is a
oduces the toxin in ev-
stem and fruit.
ts stop feeding almost
They don't have to feed
a dose that will deter
them," he says. "After
of lab work ... we
omething that can ...
plant product."
ntists familiar with the
it plants are not quite

is y it a B.t. gene
ou a selecting for an
ion that is resistant to
mes Liebman, a plant
the University of Cali-

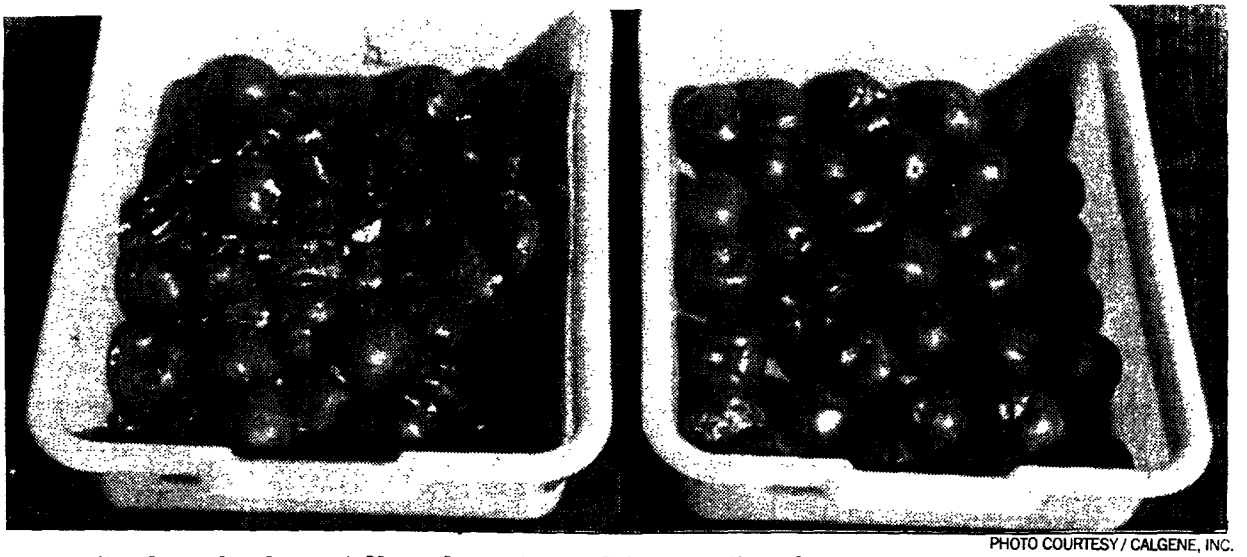


PHOTO COURTESY / CALGENE, INC.

Twenty-five days after harvest: Normal tomatoes at left are rotting; those at right were genetically altered.

fornia at Berkeley. That has happened with virtually every synthetic pesticide, starting with DDT.

In fact, Fischoff reported at a science conference earlier this year, B.t.-resistant insects have already been discovered. Monsanto says it will eventually deal with the resistance problem by using several toxins, or by developing a way to limit the toxin production to certain parts of the plant or to certain times of the growing season.

Work is also proceeding on plants that are virus-resistant. Strains of tomatoes, potatos, cucumbers and alfalfa have been developed. It's important work, because there's no chemical way to protect plants from viruses, often called "blight," or to cure infected plants.

A virus consists of two parts: an inner core made up of genetic material, either DNA or RNA, and an outer shell, called a "coat," made out of protein. To make a plant resistant to a particular virus, scientists isolate the DNA inside the virus that makes the coat and splice it into the plant's genetic code. For reasons not completely understood, if a plant is already producing the protein for a coat, the virus can't infect the plant.

Concern about hybrid forms

But some scientists are also beginning to worry about virus resistance, too. In a recent article in the Journal of Phytopathology, Dr. Gus de Zoeten of Michigan State University's department of Botany and Plant Pathology, suggested that a plant rendered genetically immune to one kind of virus could be infected by another kind; inside the plant, the genes for the two viruses could mix, forming a hybrid virus.

"The question is, are we creating new viruses by putting parts of viruses into plants, and can these parts of viruses interact with other viruses?" de Zoeten says.

The biggest danger of transgenic plants probably hasn't even been thought of, says Steven Witt, president of the San Francisco-based Center for Scientific Information and the author of three books critical of biotechnology. He sees it as a technology that should be embraced cautiously. "If you look at any new technology, the risks that will probably come back to haunt us [are the ones] nobody knows right now."

Trying to understand the emerging world of biotechnology through eyes trained to look at chemical pesticides doesn't work. Genetically-engineered plants have their own, unique dangers to match their benefits, dangers that have yet to be discovered, he says.

From the public's point of view, a crucial question is labeling. Should foods containing genetically-manipulated ingredients be specially labeled? The FDA hasn't decided.

"Under the Food, Drug and Cosmetic Act, the FDA is required to label all facts about foods that are deemed significant by consumers," says Douglas Hopkins, a senior attorney with the Environmental Defense Fund. "We believe that for a variety of reasons, consumers will conclude that the fact this is an engineered food is material them."

"We're looking at how these foods should be interpreted under the act," says Dr. James Maryanski, biotechnology coordinator for the FDA's Center for Food Safety and Applied Nutrition, who could not predict when the FDA would rule on the Calgene request. "I would not anticipate that we would label foods as genetically engineered. We would not believe that to be useful information to consumers."

The biotech industry, concerned that an altered food might be perceived as threatening, would welcome that decision.

"There is no reason to label it as 'transgenic,' " says Dr. Pamela Bridgen, executive director of the Association of Biotechnology Companies in Washington. "Transgenic plants are around all over the place, from all the breeding that has been going on for the last 100 years."

Hopkins says there are many reasons why a consumer might want to know about a foreign gene. "Vegetarians may want to know that a product that looks and feels like a vegetable product or a fruit actually contains protein from a mouse.... Another question is what the impact will be under kosher laws."

"I'm not taken in by the industry's argument, that we shouldn't label because the public won't buy this," says the EDF's Goldburg. "They've been hyping this technology as the greatest thing for the public. If it's so great, the public should want to buy it. If not, then they're trying to pull the wool over the eyes of unsuspecting consumers."

Simson Garfinkel is a freelance writer who lives in California.