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Can Plant Genetics Help Solve World Hunger? Science Says Yes

UCVoice
California roots, global reach. **FULL BIO**

UC Contributor, UC

By Jessica Dineen

When it comes to the earth's dwindling resources, climbing temperatures and burgeoning population, talk is as plentiful as it is cheap. It can also be contentious. But Dr. Pamela Ronald, professor of plant pathology at University of California, Davis, doesn't have time for controversy. She's too busy working toward an unassailable goal. “I'm focused on the greatest challenge of our time," Ronald says, “which is how to feed the growing population without further destroying the environment."

To that end, Ronald has made history. Twenty years ago, she and her colleagues at UC Davis isolated the plant-disease-battling Xa21 gene, found on the

11th chromosome of rice. The potential of this feat of genetic engineering was great; rice is relied upon to feed half the world. *The New York Times* heralded it a new agricultural era.

It's an era Ronald has continued to help define. In 2006, she worked with David Mackill and Kenong Xu at IRRI to isolate the rice gene Submergence Tolerance 1 QTL, dubbed “Sub1." Found in an ancient variety of rice, the Sub1 gene confers a flood tolerance trait to rice plants, allowing them to survive for up to two weeks underwater. A conventional rice plant will last only three or four days.

The following year, reporters from *National Public Radio* visited a village in northern Bangladesh after Monsoon flooding. Only one farmer, Gobindra Chandra Rai, had planted government-provided Sub1 seedlings developed by the International Rice Research Institute using precision breeding. The reporters encountered swaths of drowned plants surrounding Chandra Rai's plot of healthy, green stalks. Villagers crowded around, admiring the crop's success. When asked

which farmers would plant Sub1 rice in the future, Chandra Rai exclaimed, “Everybody." Last year, 3.5 million farmers in Asia were planting Sub1 rice.

Standing Up for Science

In some circles, work such as Ronald's is regarded as nearly heroic. In other circles, plant genetics garners more misgivings than accolades. When “golden rice," engineered with Vitamin A to prevent starvation and blindness, was field-tested in the Philippines in 2013, protesters ripped up the plants. *The New York Times* reported that crops with similarly benign aims were being destroyed around the world, such as grapes imbued with anti-viral properties in France.

Ronald contends that the public would be less fearful if the conversation about genetically modified crops remained grounded in science. “Many people don't realize almost everything we eat is genetically modified in some way," she says, explaining that there are many methods of altering food, some used throughout the history of farming. “Almost nothing we eat would survive in nature. It's a domesticated system."

Ronald notes that genetically engineered crops are deemed safe by widely respected organizations such as the National Academy of Sciences and the American Association for the Advancement of Science. Genetically engineered crops also get a nod for offering environmental advantages. A report issued last year by the U.S.

Department of Agriculture found less insecticide use among farmers planting Bt cotton, genetically engineered for pest resistance. “In the scientific community," Ronald asserts, “the conclusion that modern genetic methods are no more risky than conventional methods, is accepted."

The secret to assuaging fear, Ronald supposes, may be to fill out the picture "with the nitty gritty of a particular farm and a particular crop and a particular consumer."

"There's a lack of imagination among the public in the developed world," she laments. "It's hard for people to really understand that children are dying because they don't have vitamin A."

The Future of Farming

If anyone can help the public navigate the intersection of genetics, food and good health, it's Pamela Ronald. While scientists worldwide are attempting to move genes from one species to another to confer various beneficial traits, Ronald may be singularly devoted to a holistic brand of sustainable agriculture. She is married to Raoul Adamchak, an organic farmer also working out of UC Davis. In 2010, they co-authored "Tomorrow's Table: Organic Farming, Genetics, and the Future of Food," which describes the importance of ecologically based farming practices and genetically improved seed to sustainable agriculture.

If the couple's own progeny is a harbinger of things to come, the outlook is good for

scientific ingenuity. While shopping recently, Ronald and her 13-year-old daughter came across a new kind of frankenfood, a tomato fused with a potato, called a TomTato. Ronald's daughter exclaimed, “Neat, how do they do that?" Ronald described grafting. Her daughter replied, “That sounds like a lot of work. Let me know when I can get it in the seed."

Jessica Dineen covers topics ranging from the literary to the luxe, including travel, business, art, design, books, fashion, beauty, and health. Her stories and reviews have appeared in Travel + Leisure, Martha Stewart Living, Southwest Review, New England Review, and Ploughshares.

How Scientists Are Engineering Algae To

Fuel Your Car And Cure Cancer

UC*Voice*
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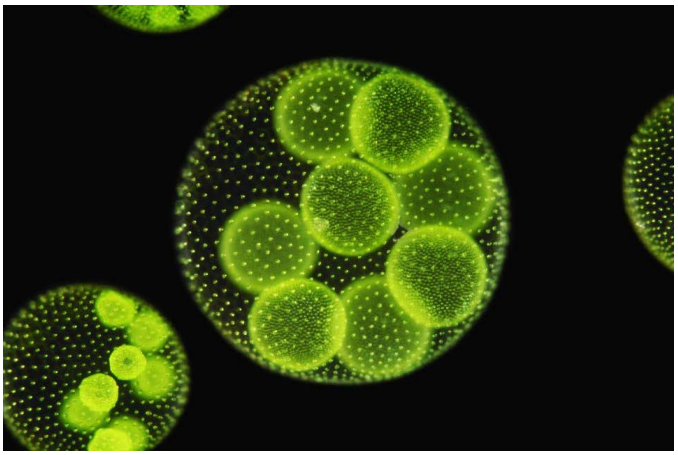
In December, UC San Diego's California Center for Algae Biotechnology Director Steve Mayfield got a call from the White House. It was the Office of Science and Technology Policy, looking for advice on improving world food security. “We hear you're Mr. Algae," they said.

The prominent research scientist was not surprised to hear from them. Algae, which Mayfield has studied for thirty years, are efficient protein additives. The tiny, single-cell organisms pack a powerful punch and have the potential to make a difference in a variety of industries. In the genetic engineering of algae, Mayfield sees nearly infinite possibilities. “We can train a little algae to do pretty much whatever we want," he says.

While the thousands of species known as algae may be a hot topic, they are nothing new. In fact, they are billions of years old and were included in the diet of the Aztecs. They are also not rare. The most prolific producers of plant oil on earth, they are capable of doubling every few hours and can grow anywhere there is water and some form of energy. “Algae are in every environment on the planet,"

Mayfield explains. “They grow in thermal hot springs, they grow in the Arctic Ocean, they grow in snow, and they grow in desert crust."



What's the End Game?

On an average day in the Mayfield lab, each of the fourteen researchers uses a high throughput machine, like fluorescent-activated cell sorters, to chase down between 100 and 200 genetic strains of algae. In one square centimeter, there can be a million cells. Once a strain is isolated, the researchers examine its molecular structure to see how well its working.

About fifteen years into studying the genes of algae, Mayfield asked himself, “What's the endgame here?" His answer: “You learn how the genes work so you can make something interesting." In 1999, he zeroed in on monoclonal antibodies. These can specifically target cancerous cells to kill them, leaving healthy cells undamaged.

Algae Entrepreneurs

Once Mayfield's lab created cancer-

fighting human antibodies, there was no looking back. “We said, what other products can algae make? Fuel? Plastics? Nutraceuticals? Animal feed? Cosmetics? A malaria vaccine? Now we make all those things."

“We develop the tools that will enable anybody to make anything," Mayfield says. When he's inspired, he doesn't stop there. Mayfield has helped start four companies: Rincon Pharmaceuticals, founded in 2004, produces monoclonal antibodies; Sapphire Energy, founded in 2007, makes algae-based fuel; Triton Health and Nutrition, founded in 2012, tackles digestive disorders; and in 2013, Mayfield started Verdant Therapeutics to create anti-cancer proteins.

Fuel of the Future

Of the companies Mayfield helped form, Sapphire Energy has caused the most ripples. Sapphire was celebrated as a potential solution to a host of problems. By 2007, the price of oil had climbed to more than $100 per barrel, high enough to warrant a search for alternatives. Energy independence and overtaxed resources had become popular discussion points among Americans. Meanwhile, there were rising concerns about carbon emissions and ensuing climate change, and all things “green" were in vogue.

There's nothing greener than algae, which offered relief on all counts. It's fast-growing, and for fuel purposes, it can be farmed in municipal wastewater, processed using existing oil refineries,

and sold in existing gas stations. Even better, algae farms do not use potable water, and algae consume global warming generator carbon dioxide.

In 2009, Sapphire received $100 million from venture capitalists, including Bill Gates. The company built a 70,000-square-foot lab in San Diego and a 22-acre farm in New Mexico. Its algae-derived fuel successfully powered cars and jets. Impressed, Exxon Mobil threw $600 million into algae oil research. *The New York Times* heralded algae-derived oil as the “fuel of the future."

With American fossil fuel production up and the price of oil down, Sapphire and other algae oil companies have put production on pause. But Mayfield considers the problem temporary. “Is algae-derived fuel realistic? Yes. Is it essential for our future? Yes." Sapphire can compete at $100 per barrel now, and the company is working toward lowering production cost and maximizing yield.

Turning Green to Gold

In spite of waning interest in algae biofuels, innovation is at an all-time high.

"Once the price of oil dropped," Mayfield explains, "all these companies said, in order to stay alive for a couple of years, we have to make high-value products."

At the 2014 Algae Biomass Summit, optimism reigned. “We're right on the edge now," Mayfield predicts, “where people are making products and getting ready to sell them." In the last month,

eight major companies have gotten in touch with Mayfield about product development. He's signed more than one top-secret deal.

These days, the Mayfield lab is busy making polyols, which can be turned into polyurethane. This summer, Mayfield expects to be riding the waves — on a surf board made of algae.

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