

Fruits of Knowledge

BY JEANNIE GRIFFITH

Horticultural scientist Susan K. Brown is mining the apple genome for the keys to some revolutionary reconceptions of a long-familiar fruit.



Apple: Read the word, and what do you see? What else but a firm, crisp, juicy, fragrant, sweet-tart red fruit, that iconic stalwart of lunch boxes and crisper drawers across America and throughout many parts of the world? Cornell fruit geneticist Susan Brown sees much more than that. How about an apple with deep red flesh, or skin patterned “like feathers on a bird’s back,” or almost as much vitamin C as an orange? How about one that doesn’t brown when you cut it or go soft in storage, or that tastes like anise, berries, or roses, or that’s loaded with cancer-preventive antioxidants?

At the New York State Agricultural Experiment Station (NYSAES) in Geneva, New York, where Brown is the Herman M. Cohn Professor of Horticultural Sciences, these apples already exist, and new possibilities—whether exotic, delicious, kind of weird, or just plain awful (think gasoline, nail-polish remover, or soap)—are literally endless.

Every Seed Holds a Mystery

Apples are as infinitely variable as the number of seeds they produce the world over, and planting a seed will never produce a tree just like the one it came from. Though a tree confers the same qualities on all the apples it bears, the five to ten seeds inside each of those apples are all unique offspring. “All apples need a pollen parent to set fruit; they can’t set fruit themselves,” Brown explains, “and the pollen has to come from a tree that’s not related genetically. It could be a crabapple. And it’s even conceivable that the seeds in an apple will have different pollen parents.”

The only way to replicate a desirable apple is to graft a cutting from the tree that produced it onto some sturdy rootstock. The trees that yield the varieties popular with consumers are all clones of solitary originals that, in the old days at least, probably grew by chance in a cider orchard or wilderness. For example, author Michael Pollan relates



Susan Brown shows off one of her new columnar apple trees.

in his book *The Botany of Desire* that the Golden Delicious apple, now grown on five continents, originated on a hillside in Clay County, West Virginia. The tree survived, as something of a roadside attraction, into the 1950s. And Pollan says that a granite monument stands in the orchard in Peru, Iowa, where the Red Delicious, this country's most popular apple, got its accidental and perilous (the farmer kept trying to mow it down) start.

Though chance and intuition will always play a role in the birth of some great apples, creating superior new varieties that will catch on with consumers involves a heavy dose of science. "Many people think that apple breeding means that I sit in my office and think of two good parents, cross them, and hope for the best," says Brown. "There have been some successful breeders who did 'plant 'em and pray,' but what we've done here is use all the latest genetic technologies, which today involves genomics."

A Century on the Cutting Edge

The apple-breeding program at NYSAES dates back to the early years of the experiment station, which was established 125 years ago. Some of the better-known varieties to come from Geneva research have included the Empire, Macoun,

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Jonagold, and Cortland, which Brown identifies as the first variety to result from a public breeding program, in 1915. "We've named 63 apple cultivars," she says.

Even with such a vaunted history, Brown saw a need for Cornell to take new directions in apple breeding. "When I came into the program in 1990, I realized that a lot of our varieties were based on McIntosh or Empire because they are ideally suited to our location." But she was concerned about the lack of genetic diversity in commercial apples. "I have really sought to save traits that I think will add to our knowledge of genes and how they can be deployed. The rootstock breeding program also does this."

Brown arrived at Cornell just as revolutionary advances in molecular genetic technology were sparking the CALS-led Genomics Initiative, now known as the New Life Sciences Initiative. The first linkage map of the apple was developed at Cornell in 1994 by Geneva professor Norm Weeden and research support specialist Minou Hemmat, PhD '80. Brown's group collaborated with Hemmat and Weeden

Joe Ogradnick, Cornell University



In Geneva, apple breeders at the New York State Agricultural Experiment Station partner with curators at the USDA-ARS Plant Genetic Resources Unit (PGRU) to preserve and explore the genetic diversity of apple.



Culinary experts Harold McGee (left), author of the highly acclaimed cookbook *On Food and Wine*, and David Arnold of the French Culinary Institute in New York City sample experimental apple varieties in Susan Brown's laboratory at the New York State Agricultural Experiment Station. The chefs spent two days last October visiting with Brown and Phil Forsline, curator of the adjacent USDA-ARS PGRU, to walk the rows of the 50-acre orchard, learn about ancient and future apples, and discuss the apple needs of chefs. In his *New York Times* column, "The Curious Cook" (November 21, 2007), McGee recounted this "fruit tasting of a lifetime." See McGee's column at www.nytimes.com/2007/11/21/dining/21curi.html.

in the publication of three additional maps, in 1997 and 1998, plus a QTL (quantitative trait loci) study on plant form and development as well as the development of markers for color, scab resistance, and self-incompatibility (the term for the apple's inability to pollinate its own flowers).

"In 1990, there were probably only 28 families of genes," Brown recalls. "A family of genes would be, for example, several genes for scab resistance. We didn't have a lot that we could use to make more efficient what was admittedly a long, expensive process. But now we have genetic markers that we can use. I can show you a small seedling and tell you whether that little seedling, when it grows up, is going to have red or yellow fruit, or have a gene for disease resistance or not. I can get scab resistance without any problem at all."

Many apple researchers, says Brown, are focused on identifying the genes that govern sweetness and acidity. But until many more markers are sorted out, planning crosses to improve flavor must rely on the most basic of techniques—tasting. "You make a cross with an understanding of the genetics of the parents. You can do tests on a seedling, but a lot of the planning of crosses depends on tastings. We taste literally hundreds and hundreds of apples a day, because there is no substitute for that. That's the challenge."

It becomes clear in listening to Brown that, beyond scientific curiosity, she is driven by a strong desire to make the apple business more profitable for the state's 674 growers. She works closely with New York stakeholders, both to find out what improvements they would like to see in apples and to have their help with grower trials of promising new varieties. "We have fruit in grower trials pretty much all throughout New York," she says.

Branching Out

While breeding new varieties of apples with highly desirable flavor, texture, nutritional content, and other fine qualities is a major goal of Brown's program today, her interest extends beyond breeding great fruit to creating trees that not only produce well but successfully resist multiple insect pests and

pathogens, and do it all while beautifully enhancing a variety of landscapes.

Brown has been given the go-ahead to recruit the first of three new genomicists to the faculty in Geneva. "Our goal is to establish a center in tree fruit genomics," she says. "We have the USDA germplasm repository, with more than 2,000 accessions of apple. We have my breeding program and the rootstock breeding program. The USDA grape group in the next building is a center of excellence in grape genomics. We anticipate that the new positions will establish collaborations with this group."

The new genomics positions are expected to include another expert in antioxidants, to complement the groundbreaking work of professors CY Lee and Rui Hai Liu, PhD '93, and a researcher in the genetics of pest and pathogen resistance. But the first position to be filled is in the genetics of tree architecture.

Apple trees, it turns out, don't have to look like a trunk with upward, out-spreading branches. Brown has fruit-bearing trees that are perfectly columnar, others that weep, and some crosses of these types that are both columnar and weeping. Her favorite type looks like a bush, with dense, upward-thrusting branches of uniform length. "All the branches stop at almost the same point," she notes. "We spend a lot of time pruning trees, trying to bring them down so that growers can get in there with ladders. This could teach us about how branches stop and also how too many branches occur."

Brown's columnar trees vary a great deal in height. "This is only a foot high; it already has an apple on it," she says, pointing to an image on her computer. "So these populations hold promise for understanding the genes involved in flowering fruit and shoot development." And in addition to offering attractive landscaping options, the columnar trees have something else going for them. "There was a drought situation, and you can see that the columnars are nice and healthy," she says, discussing another image, "while the standards aren't." So far she isn't sure how to explain the difference. "We're looking at the root system."

Brown is decidedly excited about beefing up Cornell's tree-fruit genomics program. With so much of the apple's enormous potential yet to explore, she and her colleagues can definitely use the help. "Every year we harvest at least 10,000 seeds. We have 33 acres of seedlings, which is a huge amount, and we have to evaluate them for many characteristics. We're one of the largest programs in the world."

One goal for Brown is to create an apple that can convert a new generation of children to eating fruit. She got an idea about what might work when she put crabapples in her kids' lunches as a joke and they came home raving about how good they were. "Kids like more fully flavored apples with higher acidity—that's how Granny Smith became popular," she says. "My goal is not to get kids to eat crabapples but to develop large varieties that are really powerful. I want to make apples that are really desirable to the younger market, because if they don't eat them now, then they're never going to eat them."

And if they don't eat them, there's no end to what they'll be missing.



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web urls

New York State Agricultural Experiment Station: www.nysaes.cornell.edu

Department of Horticultural Sciences: www.nysaes.cornell.edu/hort/index.html