Thomcord, a sweet, seedless grape from ARS's Parlier, California, breeders, resulted from crossing a Thompson with a Concord.

STEPHEN AUSMUS (D361-25)

GRAPES!

Our Never-Ending Crush

Maybe the first grape that you encountered was a rich, blue-black Concord, presented as sweet, squishy jelly in a deliciously gooey peanut butter-and-jelly sandwich. Later, you probably broadened your repertoire with chewy, wrinkly raisins; chilled grape juice; and fresh grapes—plump and crisp.

As a grown-up, maybe you have an occasional glass of wine, which some medical studies suggest may benefit your health.

With so many pleasurable ways to enjoy grapes, it's no wonder they're second only to oranges as America's favorite fruit. We each eat a whopping 50 pounds or more of grapes in some delicious form or another every year.

Whether it's Chardonnay or Merlot wine grapes, Thompson Seedless table grapes, or Muscat of Alexandria raisin grapes—the chocolate-coated ones you can buy at the movie theater snack counter—grapes of all kinds, from around the globe, hold the attention of Agricultural Research Service experts in laboratories from coast to coast.

These researchers are demystifying the genes that make grapes prosper and developing new and better ways to cultivate vines

BOB NICHOLS (K7721-2)

Horticulturist David Ramming heads the grape-breeding team at the San Joaquin Valley Agricultural Sciences Center in Parlier, California, known for developing many luscious grapes.

in varied ecosystems. Too, they're creating novel tactics that help vulnerable vines fend off their worst insect and disease enemies. And, they're probing the mostly mysterious but reportedly health-imparting compounds in these berries. (Technically, grapes are berries.)

Here's a closer look at what's happening at a handful of these laboratories and research vineyards.

Grape-Breeding Research Bears Delectable Fruit

Chances are good that some of those tasty seedless grapes you buy at the supermarket are the research progeny of ARS's California-based grape-breeding team. Located in the San Joaquin Valley, one of the most productive agricultural regions on our planet, the world-class team has developed an impressive array of luscious, seedless red, white, and black beauties in a grape-breeding program that dates back to 1923.

Best-sellers among them include Flame Seedless, America's favorite red seedless grape; and Crimson Seedless, planted on more than a million acres in California—the nation's leading grape-producing state. Others within the California top 10: Autumn Royal black seedless, ranked fifth; and ninth-place Princess, a delectable white seedless grape.

To develop a successful new grape, these scientists carefully select parent grape plants, cross (also known as "hybridize") them, then apply embryo rescue tactics (see box at right) to produce healthy seedlings. In 2 or 3 years, when the plants bear fruit, only about 1 of every 100 vines will be selected for further testing.

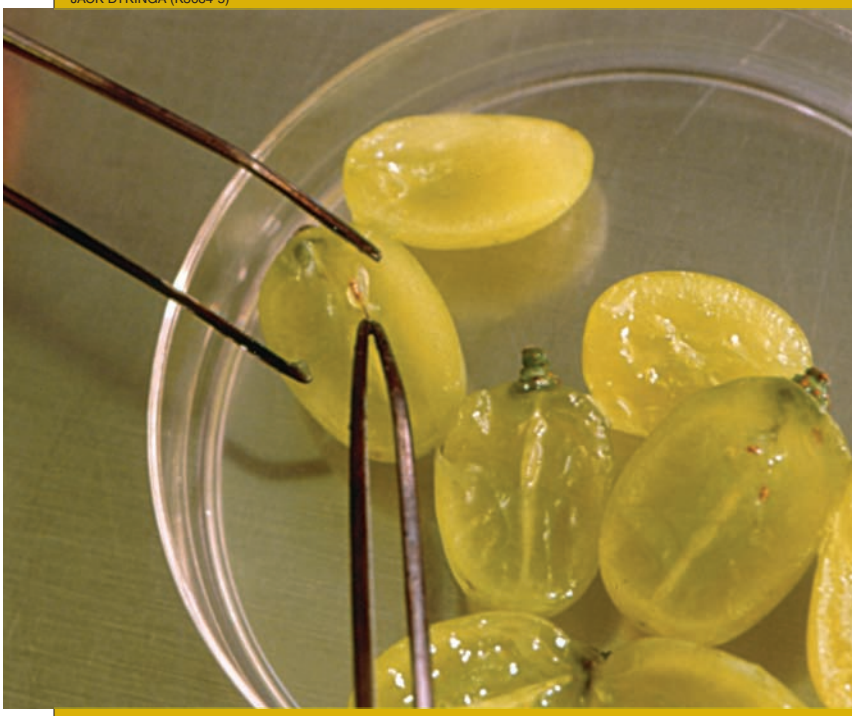
Finalists go through 8 to 10 years or more of scrutiny, including informal taste-testing and trials to see how they respond to current grape-growing practices. Grape plants have to wind their way through all these tests before researchers will make them available to nurseries and growers. That's according to horticulturist David W. Ramming. He leads today's grape-breeding team at the ARS San Joaquin Valley Agricultural Sciences Center in Parlier, California. The team's most recent offerings include two top-notch red seedless grapes and a generously sized white seedless.

Lush, Sweet Scarlets

Ramming describes newcomer Sweet Scarlet as "a specialty grape" with crunchy flesh, raspberry-red skin, and a hint of muscat flavor.

Sweet Scarlet's alluring color makes it brighter than many other red seedless grapes that ripen at the same time of year—

JACK DYKINGA (K3684-5)



An undersized seed (held at the tweezer tip) is removed from a sliced grape. The embryo inside the seed can be excised and used to form new experimental seedless-grape plants through embryo rescue, a technique pioneered by ARS scientists for grapes.

Embryo Rescue: Making the Impossible Happen

Grapes like Sweet Scarlet and Scarlet Royal likely wouldn't exist were it not for ARS scientists' expertise with a laboratory technique known as "embryo rescue." The technology "allows us to use two seedless grape plants as parents for new, seedless offspring," says grape breeder David W. Ramming with ARS at Parlier, California (see story, page 4).

"Seedless" grapes actually have a small seed inside, "but it's so small that your tongue can't detect it," says Ramming. What's the point of embryo rescue? To literally rescue the embryo within the minuscule seed so that it can be grown into an experimental vine for testing in the research vineyard.

As might be expected, when two seedless grapes are chosen as parents, the seeds inside the grapes of their offspring are also extremely small. Says Ramming, "In nature, those seeds would abort" instead of developing into hard little spheres, each with a healthy embryo inside.

To save otherwise-doomed embryos, Ramming and colleagues excise them with surgical precision from the developing berry. Then, the researchers nurture the embryos on a gel-like bed of nutrients until they form seedlings hardy enough to transplant.

Ramming pioneered use of embryo rescue several decades ago to breed superb seedless grapes. Today, it still remains the survival secret of many of the team's most innovative grapes.—By **Marcia Wood,** ARS.

about mid-August in California. In all, the mild and fruity muscat flavor, thin skin, and pleasant texture make Sweet Scarlet "a truly exceptional grape," says Ramming.

Scarlet Royal grapevines bear large, seedless berries that are "sweet, firm, and meaty," with a pleasing, dark-red color, says Ramming. By ripening in mid-August, these grapes handily fill a gap between the early-ripening Flame Seedless and the late-ripening Crimson Seedless.

"This grape is easy for growers to produce," he adds. "They'll get good yields of good-sized berries that have a full red color."

Autumn King: Ample and Appetizing

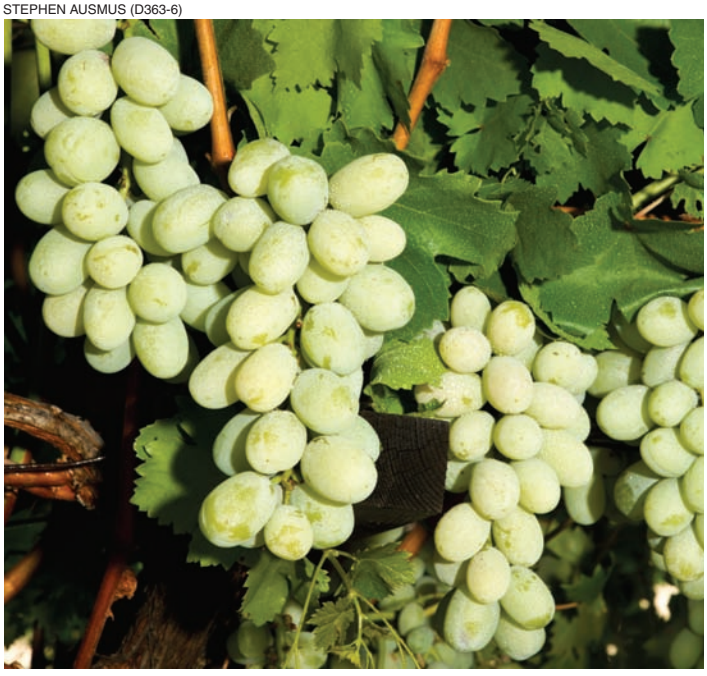
A seedless white grape, Autumn King ripens in late October in California, "taking over when the familiar Thompson Seedless harvest is winding down," says Ramming.

What's more, Autumn King holds up well in cold storage, meaning it can be stored, shipped, and sold even later in the year—while still staying sweet and firm.

"Once Autumn King gets into production," says Ramming, "you'll be able to buy a domestically grown, white seedless grape for longer than ever."

Besides terrific timing and a sweet, mild taste that's sure to please, Autumn King boasts berries that are, Ramming says, "big enough to set a new gold-standard for size among white seedless grapes."

STEPHEN AUSMUS (D363-6)



Autumn King—a plump, seedless, white grape that ripens in late October in California.

Chasing Anthocyanins

What makes a fresh-market grape like Scarlet Royal or a wine grape like Bordeaux a lovely red? The same natural compound that makes blueberries blue and plums purple: anthocyanins.

Known for infusing many of our other favorite fruits with their distinctive colors, anthocyanins belong to a broader group of compounds known as "phenolics." Some anthocyanins are healthful antioxidants that can—as their name suggests—combat harmful oxidation in the body.

To gather accurate information for growers and an increasingly health-conscious public, ARS food technologist Jungmin Lee and colleagues have worked out the precise details for a widely used technique for measuring anthocyanin levels in wine, grape juice, and other products. Lee, based in Parma, Idaho, did the work in collaboration with Oregon State University researchers Ronald E. Wrolstad and Robert W. Durst.

Anthocyanins can degrade during processing and—in the case of wine—during aging, changing a wine or juice's rich color and possibly altering its nutritional value. In Lee's laboratory, anthocyanin analyses are essential to her search for new ways to forestall unwanted loss of these compounds.

The anthocyanin assay, known as a "pH differential method," requires a spectrophotometer, a commonly used laboratory instrument. Samples take only about a half-hour to process. All told, the approach is "simple, reliable, reproducible, and economical," says Lee.

How good is the anthocyanin assay?

The Association of Analytical Communities International—an organization that evaluates new procedures for making scientific measurements—gave it preliminary approval last year. That important first step opens the door to further testing, at other laboratories, required before the technique can garner the association's final approval.

Environmental Extremes = Excellent Outdoor Lab

At Parma, studies by ARS horticulturist Krista C. Shellie may lead to new, Earth-friendly approaches to cultivating grapes. Many Idaho vineyards lie at 2,100 to 3,100 feet in this parched, high-elevation ecosystem—occasionally referred to as Idaho's "highland desert." Vines' water needs exceed the area's scant rainfall. Summers can bring blazing heat; winters can be bitterly cold.

Despite these challenging environmental conditions, Idaho's grape and wine industry has expanded steadily since the state created a commission in 1984 to promote its growth and development. Today, Idaho has more than 25 wineries, compared to only 8 in 1985. In fact, wine grapes are now Idaho's fourth-largest fruit crop.

The same environmental extremes that the region's viticulturists face make this locale ideal for Shellie's research into grapevines' natural stress-response mechanisms and how those

STEPHEN AUSMUS (D362-27)

Scarlet Royal grapes—sweet, firm, and meaty, with a pleasing dark-red color.

mechanisms might be enhanced by innovative vineyard strategies. Shellie says her findings on stress adaptation "should be applicable to wine grapes grown anyplace in the world."

Her work has already yielded some interesting details about how vines cope with water stress. The next step: to determine how those responses affect vine health and grape composition.

Protecting Grapes' Genes

The world's most widely planted grapes are varieties of what is commonly known as the "European grape," *Vitis vinifera.* The Merlot grapes that Shellie uses in her experiments at Parma, for example, belong to this particular grape species.

But grapes of every species, size, shape, color, and flavor are important to the curators at ARS's three grape genebanks. Located in Geneva, New York (see story on page 9); Davis, California; and Fort Collins, Colorado, these expansive grape collections conserve more than 3,000 different examples of wild, rare, and domesticated grapes from around the world.

The collections ensure that grapes' gene pool, that is, the species' naturally diverse array of genes, is protected for the future. Curators in Geneva and Davis grow these grapes in their research vineyards and screen-enclosed greenhouses, sending specimens to Fort Collins for indoor, ultra-cold cryopreservation storage at the backup collection there.

The Colorado laboratory, formally known as the ARS National Center for Genetic Resources Preservation, provides essential protection against outdoor hazards ranging from weather disasters like hurricanes and drought to natural enemies like the glassy-winged sharpshooter—notorious carrier of the microbe that causes Pierce's disease of grapes.

Curator David D. Ellis, in addition to overseeing his team's development of cryopreservation procedures, conducts his own laboratory experiments with specimens of more than 60 different kinds of grapes.

Cryopreservation: B-r-r-r!

Grapes pose a cryopreservation challenge because typical cryopreservation tactics that work beautifully for other crops don't work for this one.

Plant physiologist Leigh E. Towill, at Fort Collins, preserves vines' growing tips in vials suspended deep inside liquid nitrogen at about –300°F. It's too early to tell how long they will survive, notes Towill, adding, "Long-term cryopreservation methods for grapes are still in a development phase."

Though recently retired from ARS, Towill is continuing to assist with the storage studies, including experiments with warmer, shorter-term tactics. One test showed sections sliced from the woody stems of dormant grapevines can survive for a year if stored at a significantly warmer 27°F.

Muscadine grapes—used in wines, juices, jams, jellies, preserves, sauces, and glazes.

DAVID NANCE (K7858-19)

Muscadines' Plentiful Phenols May Promote Health

Muscadines pack a powerful punch when it comes to phenols—natural chemicals abundant in this southeastern U.S. grape. Many phenols have been shown to have anti-inflammatory, anticlotting, and antioxidant properties.

Muscadine phenols include resveratrol, said to lower cholesterol and risk of heart disease, and gallic and ellagic acids, not commonly found in high concentrations in other grape species.

Former Poplarville, Mississippi, horticulturist James B. Magee and Betty J. Ector, a Mississippi State University nutritionist, found significant amounts of resveratrol in the skin, pulp, and seeds of muscadine grapes.

The scientists showed that 2 ounces of unfiltered muscadine juice, one serving of muscadine jam, or one medium muscadine muffin has the same amount of resveratrol as 4 ounces of red wine, another excellent source of this heart-healthy phenol.—By **Jim Core,** ARS.

Glassy-winged sharpshooter—notorious carrier of the microbe that causes Pierce's disease of grapes.

PEGGY GREB (D9664-2)

For Muscadines: Grape Expectations

Among the grapes safely ensconced in ARS's genebank network are muscadines, or *V. rotundifolia,* the pride of the American Southeast. Native there, muscadines are grown commercially and used to make juices, jams, jellies, preserves, sauces or glazes, and what's been described as an "excellent dessert wine."

Sometimes called "Scuppernongs," muscadines love humidity and grow wild in an area extending north to Delaware and south and west to Missouri, Texas, and the Gulf of Mexico.

Commercial muscadines, which can be bronze, greenish-bronze, pinkish-red, purple, or nearly black, typically boast high yields—8 to 12 tons of grapes per acre. In addition, they have formidable resistance to a plethora of pests, including phylloxera—a highly destructive aphid—microscopic worms known as nematodes, fungal diseases such as black rot, and the *Xylella fastidiosa* bacterium that causes Pierce's disease. And, muscadines can be relatively drought-tolerant.

Stephen J. Stringer, an ARS geneticist at the Southern Horticultural Laboratory in Poplarville, Mississippi, is looking at widely used muscadine-production practices. An example: He wants to see whether compounds called growth regulators, like cytokinins or gibberellic acid, can coax plants to yield bigger—and seedless—berries. Today's commercially grown muscadines are about three-fourths-inch diameter and may have three or four seeds.

And he's breeding new and improved muscadines. Ideally, these grapes would have sought-after traits such as a thin skin; firm, juicy flesh; higher amounts of natural sugars for a sweeter taste; and increased levels of the health-imparting anthocyanins and other beneficial phenols. Muscadines are already higher in their total amount of phenols than other, better-known grapes, says Stringer (see box, page 7).

PEGGY GREB (K10115-1)

ARS's Selma Pete seedless grapes, before and after drying. These grapes dry on the vine, allowing labor-saving machine harvesting of the soft, chewy raisins.

Phenols: Phenomenal Potential?

Stringer and ARS plant physiologist Penelope Perkins-Veazie in Lane, Oklahoma, and horticulturist Donna A. Marshall at Poplarville learned more about muscadine phenols by evaluating more than 35 different kinds of commercial varieties and types used for breeding.

They found that concentrations of total phenols and of two specific phenols—ellagic acid and resveratrol—in the grapes' skin and pulp differed significantly. This diversity is one indicator of the extent to which controlled breeding could improve the kinds and amounts of phenols in new muscadines.

Already, Stringer and University of Florida colleagues have developed a new, fresh-market muscadine that Stringer describes as having "extraordinarily high concentrations of ellagic acid as well as excellent flavor and high yield potential." That grape may make its official debut later this year.

In America's history, domestication of muscadine grapes goes back at least 250 years. That, of course, is a mere blip in humankind's long-running and happy history of cultivating grapes, which may have begun as long ago as 5000 B.C.

Today, we may be learning more about these venerable vines at a faster pace than at any other time in history. And what we're discovering bodes well for a never-ending role for this favorite fruit.—By **Marcia Wood, Laura McGinnis,** and **Jim Core,** ARS.

This research is part of Plant, Microbial, and Insect Genetic Resources, Genomics, and Genetic Improvement, an ARS National Program (#301) described on the World Wide Web at www.nps.ars.usda.gov.

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