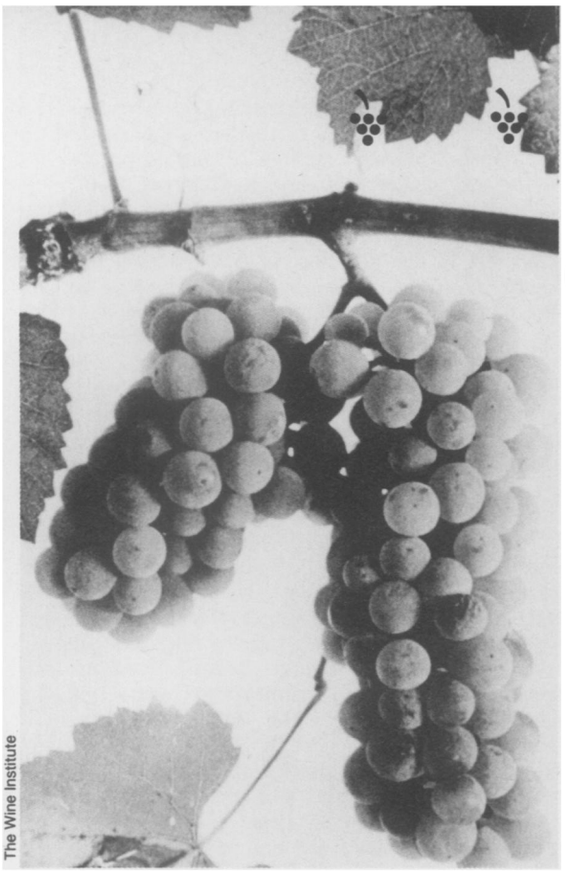

The Wine Institute

Wine's Chemical Secrets

Can science bring us better wine?

By RICHARD LIPKIN

Flood waters had just ravaged the planet, swept its valleys, drowned its animals. Life on Earth had been virtually destroyed. And yet, no sooner had the land dried out and begun to look normal, than what happened? "Noah, a man of the soil, began the planting of vineyards. He drank some of the wine, became drunk, and lay naked inside his tent" (Genesis 9:20-21).

Humans and wine. For longer than history can record, people have had an uneasy relationship with the fruit of the vine. Yet a precise understanding of what factors cause a wine to taste delicious—or dreadful—has until recently eluded even connoisseurs.

Enter the modern wine maker, who brings previously unimaginable scientific and technical finesse to civilization's most revered beverage. Ironically, the same white-coated chemists who helped pioneer genetic engineering and spectral analysis in the service of human health may also deliver a better Chardonnay.

"You can pretty much break down wine chemistry into two areas, wine quality and wine problems," says Andrew L. Waterhouse, a chemist at the University of California, Davis. "Improving wine quality is the long-term goal. But with plenty of great wines already around, the question is really how to make them more efficiently."

"As for wine problems, only a few remain to be solved," he adds. "The technical excellence of wine making today is way above what it was 30 years ago."

From her laboratory at the Australian Wine Research Institute in Glen Osmond, chemist Elizabeth J. Waters is tailing a cure for a curious wine problem—hazing. "If a white wine is mistreated—say, overheated during shipping—a cloudy suspension forms, which looks really awful," says Waters. "The problem stems from grape proteins, which precipitate at elevated temperatures. The haze isn't unhealthy, but it looks so unpleasant people won't drink the wine." To combat hazing, wine makers filter their brew in a clay called bentonite, which removes key grape proteins—but some of the preferred flavors as well. The process also leaves millions of pounds of clay waste in landfills.

In search of a way to halt hazing, Waters stumbled onto a "haze protective factor," a polysaccharide that keeps grape proteins from precipitating into clumpy clouds, she reported in August at an American Chemical Society (ACS) meeting in Chicago.

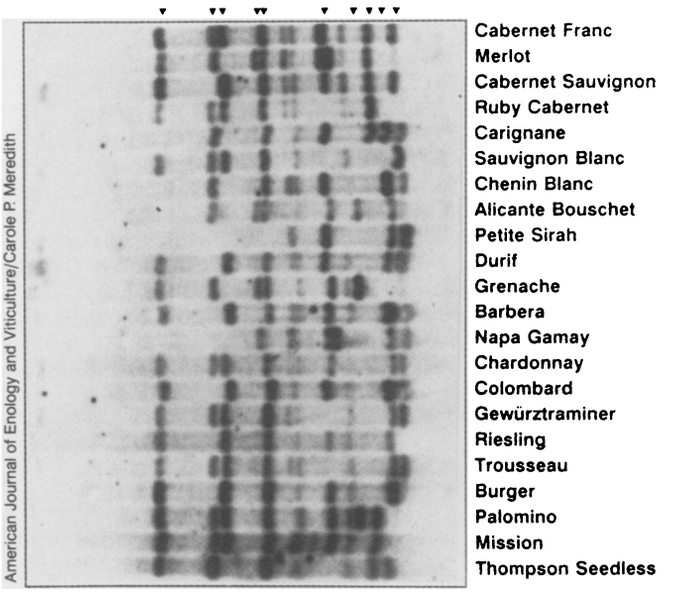
The factor, called a mannoprotein, is a natural constituent of wine yeast cell walls and is composed mostly of the sugar mannose and some protein chains. Waters believes this factor could be enriched in wines during fermentation—perhaps by letting the yeast brew longer—or added later on.

Wine haze may be unsightly, but consider the plight of the Riesling connoisseur who, after five years of cosseting a prized case, finds in his glass something that smells like kerosene. "Rieslings can form an off-flavor during storage," Peter Winterhalter, a chemist at the University of Würzburg in Germany, remarked at the ACS meeting. "It's a big problem if you store wine in a warm place, which accelerates formation of this off-flavor." But by sifting and sleuthing, he has turned up some clues to the cause of this kerosene scent.

"We know it's a glycosidically bound volatile compound," he says, found in riesling grapes and leaves. With no way to remove the compound, he aims instead to alter the chemical course of the off-flavor precursors, directing them to form a less noxious fume. Yet, there's a rub here, too. "Some people like it," he says. "A little bit of this flavor makes wine taste aged. But too much, and no one drinks it."

Searching for the sources of wine aromas and ways to "increase the good ones," J.C. Crouzet, a chemist at France's University of Montpellier, spends his days holed up in a laboratory with muscat grapes. There, he sorts out various scent agents—mostly glycosidically bound volatiles—then seeks their structures. "All fruits have aromatic compounds, but sometimes they're not in volatile form—you can't smell them. Aromas come out naturally in aging, but we want to accelerate that process."

Which aromatic compounds should be brought out? It's a wine maker's dilemma. Despite an arsenal of instruments able to discern the colloidal components in the proverbial Blood of Romance, wine quality is a purely subjective measure. A wine's flavor and texture exist for but a moment on the taster's palate.



The DNA banding patterns of 22 wine grape varieties that have undergone restriction length polymorphism analysis. Note that petite sirah and durif, once thought to be the same, in fact reveal subtly distinct genetic "fingerprints."

To pin down wine's elusive qualities and quantify each sampler's whims, Ann C. Noble, a chemist at UC-Davis, is refining a method of "principal component analysis." The technique relates aromas and flavors to specific wine compounds and grape-growing conditions. Studying such scent subtleties as the effects of monoterpenes in the muscat of Alexandria grape (a floral aroma) or the bitter and astringent taste of phenols led her to develop a wine aroma wheel – a chart that lets chemists trace a wine's fruity or woody flavor, say, to its exact chemical source. In fact, using this taste system, Noble could track 21 Cabernet Sauvignons to the soil in which each wine's grapes were grown.

For instance, Noble recently reported that Cabernet Sauvignon wines high in berry, spice, vanilla, and butterscotch flavors and aromas "are associated with older, deep, gravelly soils with low bulk densities and moderate to low water-holding capacities and nutritional levels." A complex mix of thousands of organic compounds, wine can take on subtle flavors from even trace amounts of a protein. What's more, slight changes in weather, soil, or watering can tweak wine grapes into succulence.

In California, whose 683,000 acres of vineyards yield nearly 96 percent of all U.S. wine grapes, growing conditions in the Napa Valley alone range from the low-lying, windy, marine climate of Carneros Valley to the humid hills of Howell Mountain. "From a technical standpoint, we want to know how physical factors affect vines and grapes," says James Lapsley, a UC-Davis viticulture specialist. "How do wine grapes differ? What compounds impact their flavor? In a vine's life cycle, when are its most important flavor compounds produced? How does growing environment impact grape quality?" To answer these questions, researchers subject grape vines to crowding, dryness and wetness, sun and shade, fertilizers and pesticides.

"The Europeans have been experimenting with grapes for hundreds of years, trying out many types of soils and growing conditions," adds Waterhouse. "In California, we're trying to do the same thing now, with new technology, in only a few years – and we're doing pretty well." Indeed, California wines have come of age in recent years. Once brushed off by connoisseurs, the best of California's wines now garner awards at international wine competitions.

Much research, too, goes toward breeding more robust vines, especially ones resistant to the infamous root louse phylloxera. A pest for more than 100 years in the United States and Europe, this bug has plagued California vineyards recently. Researchers are seeking phylloxera-resistant root stocks onto which they can graft prized grape plants. But many strong root systems will not accept grafts of the better grapes. So the search goes on for a robust, hybrid root that will fight off phylloxera and accept grafts of *Vitis vinifera,* the species of grape used to make most U.S. and European wines.

The phylloxera scourge ran rampant in the 19th century, largely because American and French wine makers were swapping grapes. To make matters worse, some importers – with more than 5,000 known varieties of *V. vinifera* to contend with – confused grape stocks, leaving growers unclear as to the real origin of their grapes. To sort out *V. vinifera*'s tangled genealogy, Carole P. Meredith, a geneticist at UC-Davis, enlists DNA fingerprinting to determine which vineyards are growing which grapes – and where those grapes originated. Subjecting young vine leaves and shoot tips to a gene-mapping technique known as restriction fragment length polymorphism (RFLP) analysis and then comparing the resulting patterns of DNA banding with a grape genome library, she has turned up some intriguing inconsistencies.

For instance, California zinfandel and primitivo grapes from southern Italy, normally thought to be distinct, show identical banding patterns. Furthermore, the grapes in the California wine known as Gamay Beaujolais show the same genetic pattern as those in the French Pinot Noir and its cousin, Pinot Gris. In contrast, the 100-year-old California grape petite sirah, long thought to be the same as the French grape durif, yields a different genetic pattern from its French look-alike.

"Grape genetics is a dicey issue," says Lapsley. "Wines have long histories, and wineries invest themselves heavily in a name or brand. And they don't want to change." A contentious topic, DNA fingerprinting of grapes has spawned outrage and threats of lawsuits as wine makers clamor to protect their properties, reputations – and markets. To complicate matters, French wineries have objected to the importing of U.S. wines with names like Beaujolais, referring originally to wines produced in the Beaujolais region of France – even though Californians have grown these grapes since the 1920s. "Now that we can trace the grape's genetic history," Lapsley says, "the political problem is even touchier." □

A Phenol a Day?

Ever since scientists began reporting the apparent paradox that, despite diets high in saturated fats, some French wine drinkers show below average rates of heart disease, the jury has been out on the health effects of wine.

There's still no clear verdict. But research continues into the physiological effects of wine on the human body, particularly the effects of wine phenols.

Most wines, especially red wines, contain phenolic antioxidants – chemical relatives of α-tocopherol, or vitamin E – in amounts up to 2 grams per liter. Since antioxidants can pick up disease-promoting free radicals, researchers want to see what impact, if any, wine's phenolic antioxidants have on heart disease and cancer. Areas of interest include phenol's effects on bloodborne cholesterol, hardening of the arteries, and platelet aggregation.

– R. Lipkin