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VINE ART

Art and science blend on the West Coast to create outstanding wine

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A lot of chemistry is involved in producing a good bottle of wine, and chemical scientists are key players. A wine's color, flavor, and bouquet are a result of chemical reactions, yet chemistry alone won't ensure a great wine because winemaking is also a craft built on thousands of years of tradition.

Wine is a complex mixture of compounds, consisting principally of water and alcohol along with smaller quantities of other substances such as organic acids, phenols, sugars, carbon dioxide, and sulfur dioxide. The quality of wine is also greatly influenced by the type of soil, climate, and geography, collectively known as *terroir*, a French word meaning "soil." The plant variety, vintage, and production methods also impart characteristics to the final product.

The West Coast is home to large wineries such as Robert Mondavi Corp., E.&J. Gallo, and Kendall-Jackson, but it is dominated by small independent wineries. According to the Wine Institute, the public policy advocacy association of California wineries, the estimated 1,400 commercial wineries operating in California are predominantly family-owned and -operated businesses.

California is the number one grape-growing state in the U.S., producing 90% of all U.S. wine, and more wine is consumed in the state than in any other. Washington state ranks second nationally in wine production; Oregon ranks fourth in production, after New York state. Worldwide, California is the fourth leading wine producer, after Italy, France, and Spain. This makes winemaking a big player in the state's economy, providing jobs for more than 200,000 people and racking up annual sales of approximately \$45 billion.

Wineries hire scientists for quality control and analysis. Scientists are also involved in setting optimum parameters for grape production. "With grape production, for example, it's all about flavor concentration," says James A. Kennedy, an assistant professor and wine chemist at Oregon State University, Corvallis, who focuses on phenolic chemistry for improving wine quality. In addition, he studies the influence of geography on the phenolic composition of grapes, how phenolics change during grape maturation, and how to optimize tannin structure and color stability in pinot noir grapes.

"We can strategically stress a vineyard to achieve a specific goal," Kennedy says. For example, if water is withheld from a vine, it produces smaller berries that will result in a wine with greater intensity and concentration of flavor compounds. Kennedy explains that the stressed vine puts its energy into creating grapes rather than greenery. "The trick is in knowing how far you can go before you compromise the health of the vine," he says.

Even the barrels in which wine is aged affect wine quality. "Barrels in the U.S. 40 to 50 years ago were produced primarily for whisky," Kennedy explains. "The barrels couldn't be used in the wine industry because they were highly charred. The extraction of this heavily charred wood masked important compounds produced in the grape."

Wine barrels

are made out of oak that has been aged for about two years and is then "toasted" over a fire. Depending on the toasting and aging, the wine will acquire various aromas, such as vanilla, toasted bread, honey, coffee, and chocolate.

Even the origin of the wood—French versus American oak, for example—has an impact on the wine's chemistry and, hence, the taste.



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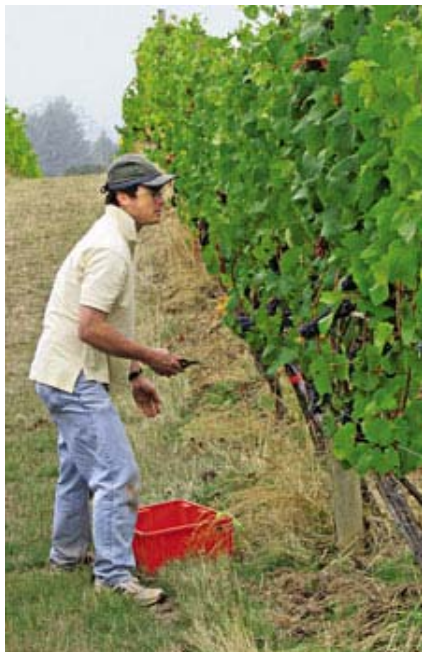
Someone who is trained as a chemist can get a foot in the door because many medium and large wineries have in-house labs. "At the undergraduate level, strong analytical skills, a good understanding of organic chemistry, and an interest in wine" can help a chemist enter the industry, Kennedy says. "The artistic part comes naturally if you have that passion and pick it up."

For many, that passion begins early. Steve Peck, head winemaker for Five Rivers Winery in Paso Robles, Calif., got his start in winemaking as a teenager with an uncle who made wine at home. Peck attended the University of California, Davis, and graduated with a degree in winemaking and chemical engineering. While in school, Peck worked harvests at Joseph Phelps Vineyards in St. Helena, Calif. "People who work in wineries enjoy what they do," he says. "Even when I worked at Genencor, I was still making five to 10 barrels a year, and many of the social retreats at work involved wine tastings and winery visits."

Five Rivers produces cabernet, pinot noir, merlot, and chardonnay wines. As head winemaker, Peck wears a number of hats. Some of his time goes into sales and marketing, managing the cellar crew, and maintaining the temperature control in the barrel rooms, and, perhaps most important, tasting the wine. "There are days when my teeth are purple by 9 AM," he says. "The most important, and probably coveted, decision I get to make is when to pick the grapes. As it gets closer to harvest time, I'm out in the vineyard walking the fields and tasting the fruit, looking for maturity. All the lab tests in the world can't test for flavor," he says.

Jordan Ferrier, who makes red wine for Hogue Cellars in Prosser, Wash., concurs: "Winemaking isn't a typical chemist's job, and anyone who thinks they're going to come in and revolutionize the industry is mistaken," he says. "The chemistry is complex, but to approach winemaking from a pure chemistry standpoint is asking for failure." Ferrier recalls a synthetic wine made in Japan, and "it was awful. Sensory science makes up a lot of what is going on in winemaking. It doesn't take HPLC to make a great wine. Winemakers determine whether a wine is good or not."

One way to ensure excellent quality is to follow your nose. Charlie Gilmore, white wine winemaker at Fetzer Vineyards in Hopland, Calif., says: "The best way to check that the fermentations are healthy is by smell. When yeasts aren't happy, they produce H₂S and other bad aromas. If we have a problem ferment, we might chill the tank to slow the yeast, feed the yeasts nutrients and nitrogen, or give the yeast some oxygen, depending on how far the fermentation has progressed. Excess nitrogen, however, begs for spoilage."



COURTESY OF JAMES KENNEDY

VITICULTURE Kennedy harvests pinot noir grapes in Newberg, Ore., as part of a study dealing with grape and wine phenolic composition.

And spoilage is an area of concern, especially when exporting wine overseas. Wines that are exported from the U.S. are subject to European Union regulations and must be accompanied by an import certification form known as a VI-1, which is a certificate of analysis and compliance with EU regulations with regard to enological practices. A laboratory chemist or enologist that has been certified by the U.S. Department of Treasury's Alcohol & Tobacco Tax & Trade Bureau (TTB) must conduct the wine analysis.

TTB certification exists because the EU and some other countries will accept only certified laboratory analysis as a condition of importing U.S. wines. This increased level of compliance requires that chemists or enologists applying for certification must submit a résumé along with both undergraduate and graduate school transcripts.

Cork taint is another major chemical concern to the wine industry, according to John Thorngate, an analytical chemist at Beam Wine Estates in Napa, Calif. Thorngate performs all the advanced chemical analyses for the seven wineries that make up Beam Wine Estates. Because he works for the group as a whole, his lab is reasonably well-equipped for gas chromatography-mass spectrometry, capillary electrophoresis, liquid chromatography-mass spectrometry, and atomic absorption spectrometry.

"About 80-90% of cork taint is due to trichloroanisole, or TCA," he says. TCA is a haloanisole that produces a musty, dank odor that can be detected by humans at very low concentrations. "Typically, the human detection threshold is 2-4 parts per trillion, and currently, most GC/MS systems are able to detect TCA at 0.5 ppt. Analyzing cork to see if it's contaminated with TCA has to be done both with a sensory panel and by instrumental analysis."

Thorngate also performs metals analysis. "I look at the copper and iron levels because both strongly affect wine oxidation. I look for 4-ethylphenol and 4-ethylguaiacol, which are volatile phenols that can be markers for yeasts like *Brettanomyces* that can spoil wine. I am gearing up to do lots of phenolic analyses; phenolic profiling is of interest to winemakers. Quality control alone is such an enormous task," he says.

Unless it's a large winery like E. & J. Gallo, which has its own R&D program, lab facilities at a winery tend to be fairly basic. Advanced analyses are sent out to independent wine analysis contract laboratories like ETS Laboratories or Vinquiry, which have more sophisticated equipment.

Vinquiry of Windsor, Calif., provides analytical and consulting support to the wine industry while providing winemaking supplies to the wine industry. It is the only wine lab in the U.S. that sells winemaking products, such as yeast and bacteria, nutrients, and chemical supplies, and it advises customers on their use. According to company President John Schilter: "Vinquiry offers analytical services that include more traditional wet chemistries while also offering newer technology such as polymerase chain reaction to report *Brettanomyces* impact on wine. We also offer HPLC analysis for 4-ethylphenol and 4-ethylguaicol and export analyses for VI-1 certification. Most wineries don't have a GC/MS, HPLC, or GC, or the time to develop the tests to be run on them. Even the larger wineries will go to an outside lab for quality control or use us as a reference laboratory."

Vinquiry has three TTB-certified chemists on staff specializing in analysis of both wines and distilled beverages. "We have quite a few M.S. chemists and enologists among our senior staff as well as several Ph.D.s," Schilter says. "Everyone on the technical side is a chemist, biochemist, or enologist or has some specialty like analytical chemistry. The quality manager has an M.S. in chemistry. We have a sensory scientist on staff at our Napa office. This is a growing part of our business because we do cork sensory analyses for clients and other consulting projects regarding wine quality throughout California," he says.

An important next step for Vinquiry is obtaining accreditation to ISO 17025 for wine, juice, and distilled beverages. ISO 17025 is an international quality standard that requires a laboratory management system and procedures and in addition requires that the laboratory be technically competent to perform specific analyses. "It is essential for any organization that wants to assure its customers of precision, accuracy, and reliability of results," he says.



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"We have a good management system in place," Schilter acknowledges, "but ISO 17025 will enhance the management of the lab and lab staff. When an accredited winery lab needs to send a sample out for analysis, they'll send it to us. We want to move from a regional lab to a national or international lab, and the accreditation is a step toward that."

ETS Laboratories,

founded by Gordon and Marjorie Burns in 1977, already has ISO 17025 accreditation. "When we first started the accreditation process, I wasn't convinced that the initial capital investment or ongoing costs of maintaining the accreditation would be justified," Gordon Burns says. "Today, I couldn't consider opening the doors if we didn't operate under the quality systems. It's very important in today's economy that the same standards for auditing are applied throughout the world," he says.

ETS, located in St. Helena, Calif., provides a variety of wine analyses from acidity to volume and weight. ETS does all its own research in an environment that is more like a medical lab with samples that need nearly immediate turnaround. "During harvest, we may receive in excess of 1,000 samples," Burns says. "The turnaround time for routine analysis is hours. We run hundreds of GC/MS analyses every day."

What Burns is most excited about is the application of microbiology and molecular biology to the wine industry. He says that new technologies are going to have a huge impact on winemaking because winemaking is primarily a microbiological activity. He expects to invest in biotechnology as he has invested in chemistry.

Several years ago, ETS developed a quality assurance test for cork taint that is used in the U.S. and became the world standard. The program has reduced the releasable TCA of corks coming through ETS for routine screening by about one-third. A more recent development at ETS is using real-time genetic analysis to detect and quantify microbial populations quickly through targeted assays. This technique detects potential spoilage-causing organisms before they cause sensory defects.

Burns says that perhaps the greatest contributions science has made to winemaking are in product quality and consistency. "There's a growing trend toward 'non-industrial wine,' " he says, "in that winemakers want to do the minimum to the wine other than to let it make itself. These winemakers understand that they need to be some of the biggest consumers of analytical services because being hands-off is only possible given an in-depth knowledge of the product and the potential hazards arriving in it. Science provides knowledge to help people make intelligent decisions in the winemaking process."

Winemaking Terminology

The vocabulary of wine production includes terms that chemists are familiar with such as oxidation and fermentation. Here are some other terms that aspiring wine professionals should know.

Brix: Measures the mass ratio of a dissolved sucrose to water in a liquid. Also written as °Bx (degrees Brix), a 25 °Bx solution has 25 g of sucrose per 100 g of liquid.

Cap: The solid part of the grape (skin, seeds, and stems) that rises to the top of the must during red wine making.

Enology: The science of wine production.

Lees: The sediment from young wines while still in the barrel, tank, or vat.

Must: The crushed grape mixture containing juice, skins, seeds, and pulp that will be fermented into wine.

Pomace: All of the seeds, skins, pulp, and stems left over after fermenting and pressing the wine.

Racking: The transfer of the young wine from one barrel to a new barrel, leaving the sediment (lees) behind. It is an opportunity for the wine to come into contact with air because a certain amount of oxygen is needed at this stage to help produce the aromas.

Tannins: Phenolic compounds responsible for the astringent and bitter taste in wines. Tannins are found primarily in the skin and seeds of the grape and are required for aging red wines. White wines have little tannin because they have minimal contact with these parts of the grape.

Terroir: The French word for "soil," terroir may also refer to the surrounding weather conditions, referred to in English as "microclimate." It may also be used to express how typical a wine is to a region.

Ullage: The empty space that develops in bottles or casks as wine evaporates. In the barrel, the missing wine is replaced to keep the wine from becoming oxidized, a process called "topping."

Viticulture: The science of grape growing.

SOURCE: www.wineeducation.com/glosa.html

Winemaking

is a trade, and while a chemistry degree is useful, a degree in enology and viticulture is more specific to the craft. Enology is the science of wine; viticulture is the cultivation of grapes for making wine. The oldest U.S. academic department in enology and viticulture is located at UC Davis and was established in 1880 as a unit of the University of California, Berkeley. The department has contributed many significant innovations and advancements in winemaking through its partnership with the industry.

Andrew Waterhouse, interim chair of the department, says his work and that of his department have a profound and direct impact on the industry. Before coming to Davis, "I had done many different things as a chemist, which really isn't an asset in a chemistry department, but in enology and viticulture, we need people who can do all kinds of chemistry," he says. "I've broadened my strengths in analytical chemistry, which is a critical area for all my students."

"Enology offers a multidisciplinary focus to winemaking," according to Susan Ebeler, Davis faculty member and graduate group chair. "Enology is a combination of chemistry, biochemistry, engineering, sensory science, viticulture, and plant biology. It really conveys an appreciation of what wine chemistry is all about. While a strong chemistry background will provide many of the tools you need to work in the wine industry, there are other skills wine chemists still need to know, like microbiology and statistics," she says.

"We train our graduates as scientists," Waterhouse says. "We are a science department with many disciplines. The real contribution we've made to the quality of California wine is that we've trained our graduates in experimental design."

We've given the industry the ability to innovate through experimentation, and that's facilitated a lot of quality improvement."

Academically, the focus of Waterhouse's research is the health and flavor effects of polyphenols, particularly the potential anti-inflammatory properties of polyphenols. (Think of the French Paradox, which purports that the French enjoy a low incidence of coronary heart disease and a long lifespan, despite a diet high in saturated fats.) Ebeler's research is in wine flavor chemistry and the chemical mechanisms related to the health effects of wine and wine components.

Overall, the industry seems to have more job openings than people to fill them. A recent look at the job postings on winejobs.com shows more than 400 open positions around the country. "We have a hard time finding interns because we're a seasonal business," says Peck. "Previous experience is a major factor, so people are doing about three harvest positions before finding a permanent job," he says. "Also, the number of producers has exploded in California. We went from 20 wineries in Paso Robles 10 years ago, and now there are 150. There are a lot of small producers that need people. The wine business has been successful and people continue to invest money into it."

Ferrier adds: "Talk to someone at a winery. The larger wineries are always looking for interns. Also, ask yourself what size scale you want to work on. At a small winery, the jobs are more varied so the winemaker is also a plumber, electrician, and retailer. Have a realistic expectation and get a couple of vintages under your belt because there's no substitute for experience," he says.

Experience abroad is also a good way to train in the industry. Gilmore worked a number of vintages for harvest at six different wineries, one of which was in Australia. He also worked in the south of France for a consultant who brought in production workers. "It's a good way to see how different wineries make wine because they all have different styles," he says. "I know people who have moved around for years; a lot of them like the travel and visiting the different cultures."

Research funding is a significant challenge in the industry. Unlike in Australia, which has a national levy on the industry to fund research efforts, research funding in the U.S. has been irregular and uncoordinated. In California, research is largely funded by voluntary donations to the American Vineyard Foundation, as well as government grants. The National Grape & Wine Initiative, launched in 2003, is working to increase research funding and to better coordinate research activity among industry, government, and academia.

Waterhouse says the inconsistent funding situation has affected the number of graduates being trained. "We've cut back on admissions because research funding has dropped. The M.S. students need research projects as part of their studies, which is hard to do when there's not much money," he says. "Industry is becoming concerned about hiring people with the right training."

The wine industry is growing and continues to grow, not just on the West Coast but nationally as well. Most operations will need well-trained employees. "It's a really exciting time," Ebeler says. "There are a lot of scientific advances in genomics, proteomics, and metabolomics. New analytical tools are becoming available to study flavor, and a lot of new science will have an impact on the industry. The distance between production and consumer isn't that wide."

Resources For The Budding Oenophile

Consumption of wine in the U.S. is not yet as widespread as in Europe, where drinking wine is a regular part of everyday dining. But as wine marketers find new ways to market wines to consumers through catchy names like "Mad Housewife" or labels that are little pieces of art, wine classes continue to grow as consumers become more interested. If you've been bitten by the wine bug and want to learn more, a wine class can expand your knowledge and appreciation. Here are a few options:

- The American Institute of Wine & Food (www.aiwf.org) is a membership organization open to anyone who is interested in wine and food. AIWF boasts 29 chapters that host wine and food programs for wine enthusiasts and professionals.
- Wine schools can be found across the country, such as the Chicago Wine School (www.wineschool.com), the Wine School of Philadelphia (winedegree.com/wx3/index.php), the Atlanta Wine School (www.atlantawineschool.com), and the New England Wine School in Rhode Island (www.newenglandwineschool.com). Wine Spectator magazine offers online courses for those who prefer to learn at their own pace (www.winespectatorschool.com).
- Colleges and universities may offer wine education classes as part of their continuing education programs. The University of Central Florida; the University of Wisconsin, Milwaukee; Cornell University; the University of Utah; and Central Washington University, for example, offer wine classes.

- Enology and viticulture degrees are offered at many institutions across the country, including [Cornell University](#); [California Polytechnic Institute, San Luis Obispo](#); [California State University, Fresno](#); [Washington State University](#); and [Oregon State University](#).
- [LocalWineEvents.com \(www.localwineevents.com\)](#) is a calendar of events both in the U.S. and abroad.

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