# Introduction: why wine science?

Wine is remarkable. Consider the following questions and statements. How can this drink of fermented grape juice have assumed such an important place at the center of many cultures, and maintained this place through millennia? How can it have spread from its origins in Eurasia some 8,000 years ago to become a frequent fixture on dinner tables across the world? People collect it, read books about it, spend large chunks of their disposable incomes on it, and some even give up their well-paid day jobs to go and make it. It has even survived (so far) the technological advances of the 20th century and the shift from largely rural-based economies to city living. Despite their best efforts, the branders and marketing wizards of modern retailing haven't been able to kill it. In non-wine producing countries it has begun to shed its predominantly elitist image and shows signs of becoming the drink of the masses.

From just one species of vine, *Vitis vinifera*, thousands of different varieties have emerged, each with their own characteristics.[1] The grapevine even has the capacity of transmitting some of the character of the site on which it is grown into the wine that it produces. As well as making drinks with myriad flavors, textures, and degrees of sweetness and astringency—many of which make perfect foils for different foods—the vine gives us a naturally alcoholic product with pleasant mind-altering and mood-mellowing characteristics.

While this book is about wine, its focus is to explore this remarkable substance through a particular lens—that of science. As an ancient drink, wine has been produced through the ages without the help of a modern scientific worldview. And many will argue that what science has brought to wine hasn't really helped it at all. Some will go so far to suggest that the so-called "advances" promoted by scientists, such as the use of pesticides, herbicides, and mechanical harvesting to help in the vineyard; and filtration, cultured yeasts, enzymes, and reverse osmosis machines in the winery, have actually been detrimental to wine quality. Certainly, there is little doubt that the potential interventions that science has made possible have been abused.

But science has a lot to offer wine, at all levels, from industrial production of mega-brands to artisanal, handcrafted boutique wines. In this introduction, I'm going to outline why I think science is a fantastically useful tool for winegrowers. Like all tools, though, it can be used correctly or abused. Indeed, one of the goals of this book will be to show how it is possible to integrate many of the most interesting and absorbing topics

1 I am aware that this is biased toward *Vitis vinifera*, and that there are many fine grape varieties with some genetic input from American and Asian vine species. Hybrids can make good wines, and in the future the new resistant varieties that are being bred with some non-vinifera genes could play an important role.

## How science works

The scientific community is a remarkable global enterprise. Researchers across the world are united by a common currency—data published in peer-reviewed scientific journals. It's an inclusive club, open to anyone, as long as they have good data and are prepared to play by the rules. How does it work? Scientists are employed by universities, government institutions, or private companies. The former will typically be paid a salary but will need to fund their work by means of grants, usually awarded by government-supported funding bodies or industry. To gain credibility and status, researchers need to publish their work in reputable peer-reviewed journals, and their publication record is how they are assessed. There are many thousands of these journals, and they vary in their scope from broad to very narrow. Not all journals are created equal, and some have much higher reputations than others. Typically, a scientist (or more commonly, a group of researchers) will write up their results and then choose the most appropriate journal to send them to. They will want to have them published in the highest-ranking journal possible (journals are ranked, for example, by the average number of times a paper published there is cited, with the status of the citing article borne in mind—it is called an "impact factor"), but they won't want to send their paper to a journal where it will be rejected, because of the delay in publication that will ensue. How do journals decide which papers to accept? This is where *peer review* kicks in, a process vital to the integrity of the scientific literature. Each journal has a board of editors made up of leading researchers in the field covered by the journal, and also a larger pool of scientists willing to act as referees for papers in their chosen subject areas. A paper coming in will be assessed by one of the editors: if it is clearly unsuitable it will instantly be rejected, but if it is potentially good enough, it will be sent out to two or more scientists for review. They will prepare a report on the paper, checking that it is correct, is suitable for the journal it has been submitted to (if it is a high-ranking journal, are the results exciting, novel, and significant?), and that the science is good. If they recommend it to be accepted, they might also suggest possible revisions or further experiments. Then the paper and the referees' reports are sent back to the editor, who makes a final decision whether to accept it, accept it with revision, or reject it. Getting your paper into one of the elite band of leading journals can make your career. It should be pointed out that peer review is a slightly controversial process because (1) it involves scientists reviewing the work of their peers who may well be their competitors, (2) it can take a long time, and (3) because some consider it not to be as rigorous as it should be since good papers are sometimes rejected while less good ones get through.

Science is highly competitive. The entry ticket into the scientific community is a doctorate (a PhD), which is awarded by a university for the successful completion of an acceptable thesis (a written account of research undertaken on the subject of choice). This typically takes from three to five years to achieve. But getting a PhD does not guarantee a research job. After you complete it you need to do what's known as a postdoc (postdoctoral research position), a short-term (usually three years) contract to work as a researcher in someone else's lab. After two such positions (preferably with one abroad), if you've been reasonably successful and have published several papers in good journals, then it's time to try to land a proper research job. These are few and far between, and competition for them is fierce. For those who succeed, though, running a successful research group is a highly rewarding career, albeit one that requires grueling hours and absolute commitment.



in wine with a scientific understanding of these issues, and that such an integration will assist in the production of more interesting, compelling wines at all levels. Even if your goal is to produce manipulation-free "natural" wine, a good grounding in wine science will help you reach this target with fewer disasters along the way. As an example, people pay a lot of money to buy wines coming from a particular patch of ground, or "terroir." Wine science will help us understand what is special about that vineyard site and may thus facilitate the identification of similarly endowed sites or help in the production of better wines from vineyards less blessed by nature.

### SCIENCE IS USEFUL

The scientific method provides us with an incredibly useful toolkit. It helps us overcome our biases and prejudices and allows us to answer difficult questions. It helps us to be objective. It presents a coherent model of the world around us that assists our understanding of this environment and enables us to develop new technologies that actually work.

It needs to be emphasized that objectivity is one of the keys to the successful practice of science. By nature we are not objective. We are pulled and pushed in various directions by our built-in preconceptions, predilections, and prejudices, often subtly, sometimes not so subtly. We frequently display confirmation bias, recruiting pieces of evidence that fit with our narrative of the world around us. Good scientists will step aside and try, as much as is possible, to be ruthlessly objective about the phenomena they are studying. The two arms of scientific enquiry are observation and experiment. Scientists look at what's there, formulate hypotheses, and then test those hypotheses by experiment, trying their hardest to disprove them. This is the only way they can be sure that they are correct.

Let's make this practical. Imagine you had a novel chemical treatment that you thought would protect your vines from mildew. How would you test it? Well, you could try treating all your vines with it and then see how they do. There is a problem with this approach, though. If you get positive results, how do you know they are attributable to your treatment, and not, for example, to the benevolent conditions of this particular vintage? The answer is, you don't. This is where the scientific method helps.

A more rigorous and useful approach is to compare the treated population of vines with what scientists term a "control," in this case, a group of vines that have not been treated, or more precisely a group of vines that have been sprayed with an inert substance according to the same schedule as the test group, to rule out the possibility that it is the act of spraying that is having the effect, rather than anything specific to the chemical. So you split your vineyard into two and treat just one half. Still, there is a problem with this experiment. In any vineyard there will be natural variation, and any significant results might be because one part of the vineyard enjoys better conditions than the other (it might be slightly warmer or have different drainage properties. The answer? Subdivide the vineyard further into dozens of different plots, and randomize the treatment such that plots that are treated are interspersed with those that aren't in a way that evens out the environmental variation.

So do we go ahead? Not yet. Once we get our results we will need to know whether any beneficial effect is significant. That is, what is the likelihood that such a benefit could have been obtained by chance, through natural variation in the measured populations? This is where statistical analysis steps in. Statistics is intrinsic to any good experimental design. Good experiments should be designed from the start with statistical analysis in mind: how many replications (repeated observations) will be necessary to produce a significant result? This can be worked out in advance. Whenever you see a graph or table presenting experimental results, your first question