CHAPTER 1

Viticulture – the basics

The aim of the grape grower is, following a successful annual vineyard cycle, to harvest ripe and healthy grapes, of the quality and to the specification required for subsequent vinification. The grower and winemaker are both aware that any deficiencies in the quality of the fruit will affect not only the quality of the wine but also profitability. In this chapter, we will examine the grape vine and its fruit in some detail. We also look at the reasons why vines are grafted onto rootstocks, including the devastating effect of the *Phylloxera* louse, and why crossings have been developed.

1.1 The grape vine

The cultivation of the grape vine is known to have begun some 8000 years ago in the Near East. Archaeological evidence of cultivated grape pips has been found in the Republic of Georgia and dated 6000–7000 BC. A potsherd (fragment of pottery) found in Iran and dated around 5000 BC has been analysed and found to contain salt from tartaric acid, which could only have come from grape juice, and resin used as a wine preservative. Wine presses from 2000 to 3000 BC have been found in south-eastern Turkey. In the ensuing millennia, viticulture spread throughout Europe and parts of Asia, and, in the last 230–460 years, also to New World countries.

The grape vine belongs to a family of climbing flowering plants called Vitaceae (formerly Ampelidaceae). The family comprises 15 genera, including the genus *Vitis*, the grape-bearing vine. This genus comprises some 65 species, including *Vitis vinifera*. It is worth noting that the members of any species have the ability to exchange genes and to interbreed. *V. vinifera* is the European and

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central Asian species of grapevine, and it is from this species that almost all of the world's wine is made.

1.2 Grape varieties

V. vinifera has, as we now believe, some 10,000 different varieties, e.g. *V. vinifera* Chardonnay, *V. vinifera* Cabernet Sauvignon. Each variety looks different and tastes different. Some varieties ripen early, others late; some are suitable for growing in warm climates, others prefer cooler conditions; some like certain types of soil, others don't; some yield well, others are extremely shy bearing. Some can produce first-class wine, others distinctly mediocre. An illustration of some of the grape varieties planted in Argentina is shown in Figure 1.1.

Whilst these are all factors of relevance to a grower, the actual choice of variety or varieties planted in any vineyard may well, as in the European Union (EU), be determined by wine laws. For example, red Beaune must be made from the variety Pinot Noir. It is worth remembering that most of the varieties that we know have been cultivated and refined by generations of growers, although some such as Riesling are probably the descendants of wild vines.

The grape variety, or blend of grape varieties, from which a wine is made is a key factor in determining the design, style, aromas and flavours of the wine. Wines made from a single variety are sometimes referred to as varietals. The name of the variety may be stated on the label, this concept having been introduced in Alsace in the early 1920s and promoted heavily by the Californian producers in the 1970s, and has now become commonplace. However, many

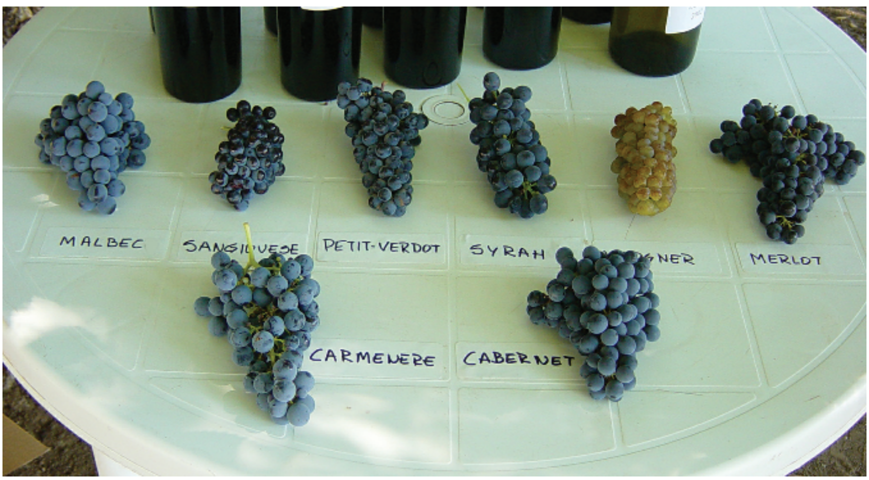

Figure 1.1 Some grape varieties planted in Argentina.

wines made from a single variety do not state the fact on the front label, e.g. a bottle of Chablis will rarely inform you that the wine is made from Chardonnay. Many top-quality wines are made from a blend of two or more varieties, with each variety helping to make a harmonious and complex blend. This may perhaps be compared with cooking, where every ingredient adds to taste and balance. Examples of well-known wines made from a blend of varieties include most red Bordeaux, which are usually made from two to five different varieties (Cabernet Sauvignon, Cabernet Franc, Merlot, Malbec, Petit Verdot), and red Châteauneuf-du-Pape where up to 13 can be used.

Of the 10,000 or so different grape varieties, only 500 or so are commonly used for winemaking. The names of just a few of these, e.g. Sauvignon Blanc, are very well known. Some varieties are truly international, such as Chardonnay, which is planted in many parts of the world. Others are found in just one country, or even one region within a country such as the Mencia variety in north-west Spain. Many varieties have different names in different countries and even pseudonyms in different regions of the same country. So, for example, southern Portugal's Fernão Pires changes its name to Maria Gomes further north in Bairrada, and Croatia's Trbljan has perhaps 13 synonyms within the country.

Discussion of the characteristics of individual grape varieties is a detailed topic and is beyond the scope of this book. For further information, the reader is referred to the Bibliography.

1.3 The structure of the grape berry

Although the juice of the grape is seen as the essential ingredient in the winemaking process, other grape constituents also have roles of varying importance, and we will briefly examine these, including their impact upon the wine produced.

Figure 1.2 shows a section through a typical ripe grape berry.

1.3.1 Stalks

A cluster of grape berries includes a considerable amount of stems (stalks). The individual stalk of each berry is the pedicel, which is attached to the rachis, or main axis stem of the cluster. The cluster is attached to the vine by the peduncle, and it is this stem that is usually cut by the grape picker, if the fruit is being harvested by hand. Stalks contain tannins that may give a bitter taste and an astringent feel to wine. Whether or not the stems are included in early stages of the winemaking process is a matter of choice, depending on the style required. The winemaker may choose to destem the grapes completely before they are crushed. Alternatively, the stalks, or just a small proportion of them, may be left on to increase the tannin in red wine to give

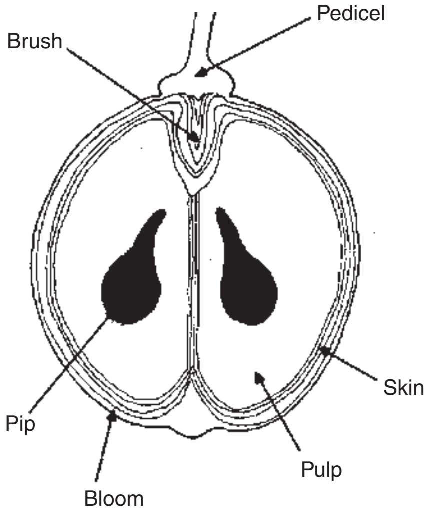

Figure 1.2 Structure of the grape berry. Source: Courtesy of Christopher Willsmore.

extra structure. Also, if the stalks are not removed, they perform a useful task in the pressing operation by acting as drainage channels, helping to prevent juice pockets.

1.3.2 Skins

Skins contain colouring matters, aroma compounds, flavour constituents and tannins. There are several layers of skin; the outside waxy layer with its whitish hue is called bloom. This contains yeasts and bacteria. Below this, we find further layers containing complex substances called polyphenols (a class of flavonoids), which can be divided into two groups:

1 *Anthocyanins (black grapes)* and *flavones (white grapes)* give grapes their colour, and as phenolic biflavanoid compounds, they form antioxidants which help preserve the wine and perhaps provide health-giving properties. The predominant anthocyanin in *V. vinifera* grapes is malvidin 3,5-diglucoside ($C_{29}H_{35}O_{17}$).
2 *Tannins* are bitter compounds that are also found in stalks and pips. They can, if unripe or incorrectly handled, give an excessively dry, green or bitter mouth feel on the palate. Tannin levels are higher in red wines where more use is made of the skins in the winemaking process and with much greater extraction from the skins than in white and rosé wines. Tannin gives full-bodied red wines 'grip' and firmness in the mouth. Some varieties such as Cabernet Sauvignon, Syrah and Nebbiolo contain high levels of tannins; others such as Gamay have much lower levels.

1.3.3 Yeasts

Yeasts are single-celled micro-organisms belonging to the Fungi kingdom. Their usual method of reproduction is by budding. There are over 1500 species, of which just a few are of interest to the winemaker. The enzymes in yeasts are, of course, essential for the wine-fermentation process. Yeasts, together with bacteria, attach themselves to the bloom on the skins of grapes. There are two basic groups of yeast present on the skins:

- Wild yeasts: these are mostly of the genera *Kloeckera* and *Hanseniaspora*. Wild yeasts only operate aerobically. Once in contact with grape sugars, they can convert these sugars to alcohol, but only up to approximately 4% alcohol by volume (abv), at which point they die.
- Wine yeasts, of the genus *Saccharomyces* (sugar fungus). These can operate both aerobically and anaerobically. During a fermentation, they may continue to work until either there is no more sugar left in the juice or an alcoholic strength of approximately 15% has been reached, at which point they die naturally.

1.3.4 Pulp

The pulp or flesh contains juice. If you peel the skin of either a green or black skinned grape, the colour of the flesh is not dissimilar. The actual juice of the grape is almost colourless, with the very rare exception of a very few varieties that have tinted flesh, e.g. Gamay Teinturier and Dunkelfelder. The pulp contains water, sugars, fruit acids, proteins and minerals:

- Water: approximately 70–80% of the grape pulp is water.
- Sugars: when unripe, all fruits contain a high concentration of acids and low levels of sugar. As the fruit ripens and reaches maturity, the balance changes, with sugar levels rising and acidity falling. Photosynthesis is the means by which a greater part of this change occurs. Grape sugars are mainly represented by fructose and glucose, with each comprising between 8 and 12% of the weight of a ripe berry. Sucrose, although present in the leaves and phloem tubes of the vine, has no significant presence in the berry because having been transported into the grape, it is hydrolysed into its constituents. As harvest nears, the producer can measure the rise in sugar levels by using a refractometer, as illustrated in Figure 1.3.
- Acids: tartaric acid and malic acid account for between 69 and 92% of the acidity of the grape berry, the latter being of a higher proportion in unripe grapes. During the ripening process, the amount of malic acid decreases, and tartaric becomes the principal acid. In fact, the amount of tartaric acid remains constant, but it is diluted as the grape berry swells. Tartaric acid is not found in significant quantities in any other cultivated fruits of European origin, although it is a component in bananas, mangos and tamarinds. Acids have an important role in giving wine a refreshing, mouth-watering taste and also give stability and longevity to the finished product. There are

Figure 1.3 Refractometer.

tiny amounts of other organic acids present in grapes, including acetic, citric and succinic acids. Amino acids are also present in tiny amounts, mainly arginine and proline.

- Minerals: potassium is the main mineral present in the grape pulp, with a concentration of up to 2500 mg/l. Of the other minerals present, none has a concentration of more than 200 mg/l, but the most significant are calcium, magnesium and sodium.

1.3.5 Pips

Pips or seeds vary in size and shape according to grape variety. Unlike with stalks, there is no means of separating them at reception at the winery and, if crushed, will impart astringency to the wine owing to their bitter oils and hard tannins. As we shall see later, modern presses are designed to minimise this happening. We will discuss grape-berry development in Chapter 4.

1.4 Crossings, hybrids, clonal and massal selection

1.4.1 Crossings

It is possible to cross two varieties of *V. vinifera* (by fertilising one variety with the pollen of another variety) and thus produce a *crossing*, itself a new variety. For example, the variety Marselan is a crossing of Cabernet Sauvignon and Grenache, and was bred in 1961 by the French National Institute for Agricultural Research (INRA). The aim of breeding the crossing was to create a disease-resistant variety with the heat tolerance of Grenache together with the elegance and finesse of Cabernet Sauvignon. It should be noted, however, that a crossing will not necessarily inherit the characteristics of its parent varieties.

1.4.2 Hybrids

It is important not to confuse the term *crossing* with *hybrid*. A hybrid is a 'crossing' of two vine species. Hybrids, in the first half of the twentieth century, were planted extensively in France, but during the 1960s and 1970s, some 325,000 hectares (ha) were grubbed up. The use of hybrids is prohibited in the EU for the production of wines of the Protected Designation of Origin (PDO) category, in theory the highest quality level.

1.4.3 Clones and massal selection

From any variety, breeders can select individual clones. Clonal selection is basically breeding asexually from a single parent, aiming to obtain certain characteristics such as yield, flavour, good plant shape, early ripening, disease resistance, etc. Each vine will be identical in DNA and 'personality'. Planting of vineyards with single clones of a variety became commonplace in the 1970s to 1990s. However, in spite of the tremendous development with clonal selection during the past 40 years, many growers believe that old vines give the highest-quality juice. Massal selection involves taking cuttings from outstanding and perhaps old vines in a vineyard and propagating the budwood. This process is now regaining popularity. Research on genetic modification of vines is taking place, but at present no wine is produced from genetically modified plants.

1.5 Grafting

Although nearly all the world's wine is produced by various varieties of the species *V. vinifera*, the roots on which the *V. vinifera* vines are growing are usually those of another species, or hybrids of other species. Why is this? *V. vinifera* has already been described as the European species of vine, because of its origin. Other species of grapevine exist whose origins are elsewhere, particularly in the Americas, e.g. *Vitis rupestris*. However, although these other species produce grapes, the wine made from them has a most unpleasant taste. Therefore, *V. vinifera* is the species that is used to produce almost all of the world's wine.

At the time that the countries in the New World were colonised, it was obvious that wine could be produced in parts of many of them, but *V. vinifera* needed to be brought from Europe in order to produce palatable wines. However, *V. vinifera* had no resistance to the many pests and diseases that existed in the New World. Disastrously, during the late nineteenth century, these pests and diseases found their way from the USA to Europe on botanical specimens and plant material. The vineyards of Europe suffered initially from mildews, which will be detailed in Chapter 5, and then from a most lethal pest, *Phylloxera vastatrix*, that eats into the roots of *V. vinifera*, resulting in the vines dying.

1.6 *Phylloxera vastatrix*

Of all the disasters that have struck the vineyards of Europe over the centuries, the coming of *Phylloxera vastatrix* (recently reclassified as *Daktulosphaira vitifoliae*; see Chapter 5) was by far the most devastating. It was first discovered in 1863 in a greenhouse in Hammersmith, London, and named *Phylloxera* in 1868, the same year as the pest was found in vineyards in the Rhône valley in France. It was noted in Bordeaux in 1869, and by 1877 it had arrived in Geelong in Victoria, Australia. It was found in New Zealand in 1885.

Phylloxera had lived in North America, east of the Rocky Mountains, for thousands of years. Naturally the American species of vines had become resistant, the roots having developed the ability to heal over after attack. As the pest wound its devastating way throughout the vineyards of France, into Spain and elsewhere during the latter years of the nineteenth century, many attempts were made to find a cure. Poisoning the soil and flooding the vineyards were two of the ideas tried, which now seem extreme. Many growers simply gave up, and in many regions the amount of land under vines shrank considerably. In the Chablis district of Burgundy, there were some 40,000 ha of vines prior to the arrival of *Phylloxera*, and owing to the invasion of the pest (together with crop losses owing to spring frosts) this had shrunk to 550 ha by the end of the Second World War.

Phylloxera is an aphid that has many different manifestations during its life cycle, and can breed both asexually and sexually. An illustration of *Phylloxera* in its root-living form is shown in Figure 1.4. When reproducing asexually, eggs are laid on the vine roots and hatch into crawlers. These develop into either wingless or winged adults. *Phylloxera* only feeds on the roots of *V. vinifera*. The vine's young, feeder roots develop nodosities – hook-shaped galls. The older, thicker, storage roots develop wart-like tuberosities. The cambium and phloem are destroyed, preventing sap from circulating and synthesised food being transmitted downward from the leaves. Root tips can be killed by a process of strangulation by the canker. It must be stressed that *Phylloxera* affects the very life of the vine rather than the quality of the grapes and resulting wine.

As we have seen, the grapes of American species of vines make unpleasant-tasting wine. However, if a *V. vinifera* plant is grafted onto an American species rootstock (or a hybrid of two American species), then the root is resistant to attack. The grafted plant yields quality grapes perfectly suitable for winemaking. The primary functions of the roots are to provide anchorage for the vine and to draw up water and nutrients, including trace elements that will help give the wine flavours. So, producers almost the world over began grafting their vines. The economic cost of *Phylloxera* is huge – the cost of purchasing grafted vines from a nursery may be four times that of ungrafted material.

Although the vast majority of the world's vines are now grafted, there are still several areas where ungrafted vines are common, including Chile, areas of Argentina and most of the Mosel in Germany. *Phylloxera* will not live in certain

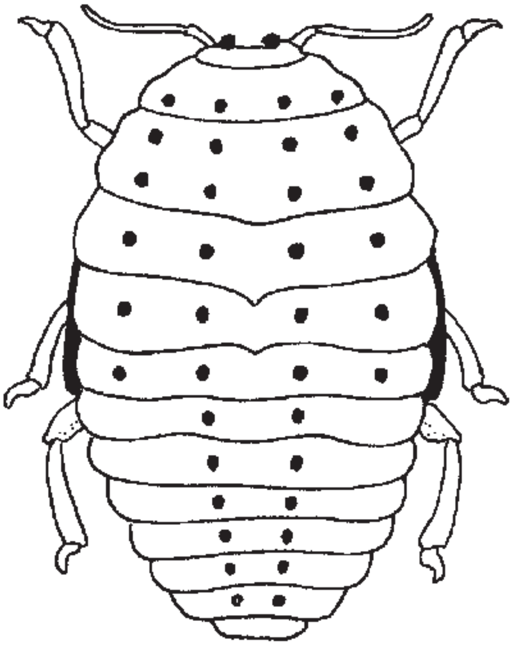

Figure 1.4 *Phylloxera* louse. Source: Courtesy of Christopher Willsmore.

soil types, including sand and slate. The states of Western Australia, South Australia and Tasmania are *Phylloxera*-free. For *Phylloxera* to spread, it is usually transmitted on plant materials, grapes, clothing, tools, picking bins or vehicles – unless transported, the aphid will spread only a hundred metres or so in a season. So, as in Chile and the *Phylloxera*-free parts of Australia (known as *Phylloxera* Exclusion Zones), a rigorous quarantine programme has excluded the louse, for its arrival in the vineyards could spell economic disaster. To prevent any risk of the aphid spreading on equipment, this must be thoroughly disinfected or heat treated. For example, tractors may be put into a chamber and heated to 45°C for 2 h; picking bins may be heated to 70°C for 5 min. New vine planting material must also be heat treated: 50°C for 5 min is effective.

1.7 Rootstocks

There are many different American species of vines, and just a few of these are suitable for rootstocks. Three of the most widely used are *Vitis berlandieri*, *Vitis riparia* and *Vitis rupestris*. The choice of species for rootstock will depend not only on the vine stock, but also on the climate and soil type. Most commercially used rootstocks are hybrids of two American species. Table 1.1 describes several rootstocks in common usage. In some regions, the grafting

Table 1.1 Some rootstocks in common usage

Rootstock name	Hybridisation	Characteristics
Richter 110	*berlandieri/rupestris*	Fairly vigorous. Suitable for shallow soils. Resistant to 17% active limestone. Moderately drought-tolerant.
Ruggeri 140	*berlandieri/rupestris*	Vigorous. Grows in exhausted soils. Resistant to 30% active limestone. Very drought-tolerant.
Paulsen 1103	*berlandieri/rupestris*	Very vigorous. Fair resistance to salinity. Resistant to 17% active limestone. Moderately drought-tolerant.
SO4	*berlandieri/riparia*	Average vigour. Suitable for poorly drained soils. Resistant to nematodes. Resistant to 20% active limestone.
101–14	*riparia/rupestris*	Average vigour. Suitable for alluvial soils. Low resistance to active lime.

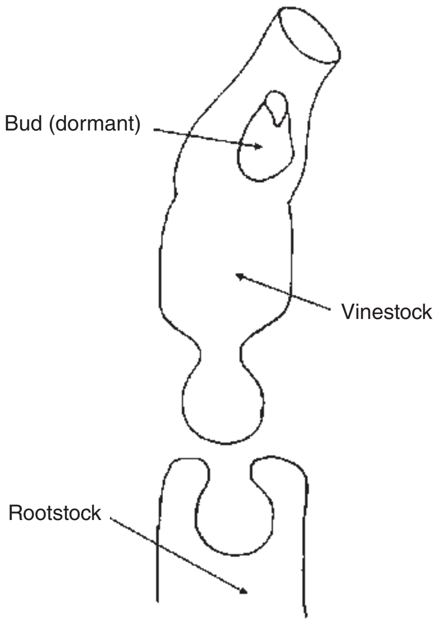

Figure 1.5 Graft – omega cut. Source: Courtesy of Christopher Willsmore.

of vines still takes place in the vineyards, but it is usual for producers to buy new vines from specialist nurseries, where they have been bench-grafted. The grower wishing to establish a new vineyard, or replace existing vines, will order from the nursery a specified clone of a variety of *V. vinifera* pre-grafted onto a suitable species or hybrid of root stock. The most common type of graft used nowadays is the machine-made omega cut, as illustrated in Figure 1.5.

Some rootstocks that were once considered to be *Phylloxera*-resistant (e.g. rootstock AXR1) were found not be, in the late twentieth century. Expensive lessons were learned by many a Californian grower. It is also argued that in recent decades, there has evolved a new, even more troublesome biotype of *Phylloxera vastatrix*. Before leaving the topic of rootstocks, we should note that in addition to the primary functions discussed above, roots produce hormones, including cytokinins and gibberellins that stimulate and regulate growth, and control other plant functions.

1.8 The life of the vine

Grapevines can live for over 100 years, but the lifespan will depend upon many factors, including the climate of the country/region in which they are planted, the soil type and the methods of viticulture. In the first few years after planting (3–5 years) as the vine establishes its root system, yields will be naturally low. Even so, such small yields from the young vine can sometimes give intense flavours, and classic varietal character.

As vines grow older, their root systems become more complex with deeper penetration of the ground in search of water and nutrients. It is generally accepted that older vines give particularly good fruit which, of course, can lead to more concentrated and intense wines. After about 20 years, vines start to become less vigorous, thus producing smaller yields. Accordingly, some producers have a replanting cycle to ensure there is no drop in production. They may, for example, decide to replant vineyards when the vines have reached a certain age – perhaps 30–40 years or so. In areas where there are problems with virus, a vineyard could be grubbed up when the vines are just 20 years old. In the best vineyards, producers will often replace diseased or dying vines on an individual basis, to retain a high average age. Ungrafted vines can have the longest life of all, and there are a few areas in the world where some vines aged 120 years or more still thrive, such as the Grosse Lage (Grand Cru) vineyards of the Dr. Loosen Estate, in the Mosel, Germany.