VITICULTURE

CHAPTER FOUR

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LEARNING OBJECTIVES

After studying this chapter, the candidate should be able to:

- Describe the physical structure of a grapevine.
- Explain the annual life cycle and metabolic processes of the vine.
- Identify the factors that affect the amount of sugar and acid in grapes.
- Recognize the elements that make up the concept of terroir.
- Recall the effects of vine diseases, pests, and botrytis.
- Understand how viticultural practices such as organic, biodynamic, and sustainable differ from those of mainstream viticulture and from each other.

Globally, grapevines cover nearly 19 million acres (7.7 million ha) and produce more than 70 million tons of fruit annually, making grapes the world's most important fruit crop. Of this output, 70% goes into wine; the rest is used for table grapes, grape juice, or raisins.

Viticulture is the term used for the branch of agriculture that specifically deals with the intentional cultivation of grapevines. Viticulture is an art that has been practiced for millennia. When grapes are grown specifically to make wine, as opposed to juice or for use as table grapes, viticulture is sometimes called *winegrowing*. Today, winegrowing runs the gamut from tiny plots tended by a single farmer using ancient farming methods to vast tracts tended by a small army of trained viticulturists using high-technology equipment and machinery.

THE GRAPEVINE

PHYSICAL STRUCTURE

The vine, as cultivated, consists of a single *trunk* that connects its underground root system to the aboveground structure of branches, shoots, and leaves. The roots continue to grow and spread throughout the lifetime of the vine, eventually creating an elaborate network far larger than the visible plant, capable of pulling water and nutrients from soil deep below the surface. The trunk thickens slowly with time, growing from a slender stick to a gnarled, tree-like pillar after many years.

From the trunk, a well-maintained vine will usually have one or two branches, sometimes called *arms*. These start as *spurs* that develop into young, thin *canes*. During annual pruning, most canes are removed. However, those that are retained from season to season will eventually form thicker arms known as *cordons*. Most trunks are encouraged to have one or two arms, but in some vineyards the vines may be allowed to grow in a more complex arrangement with four or more limbs. Without intervention, the vine would quickly develop an unruly tangle of multiple canes, which is why pruning and training are important. The vine's arms support the leaves and grape bunches that grow seasonally. This entire portion of the vine, including the fruit, is referred to as the *canopy*.

Grapes, like all fruits, are seed repositories. The skin and pulp of the grape are designed to protect the seed from damage and nourish it while it matures. The green skin provides camouflage, and the pulp is so acidic that it dissuades consumption. As the seed approaches maturity, the skin develops an attractive red or gold coloring, while the pulp becomes increasingly sweet and juicy, encouraging birds or other animals to eat the grapes or carry them away, thereby spreading the seeds. When the pulp is near its maximum sweetness and the seeds are mature, the grapes are said to be ripe.

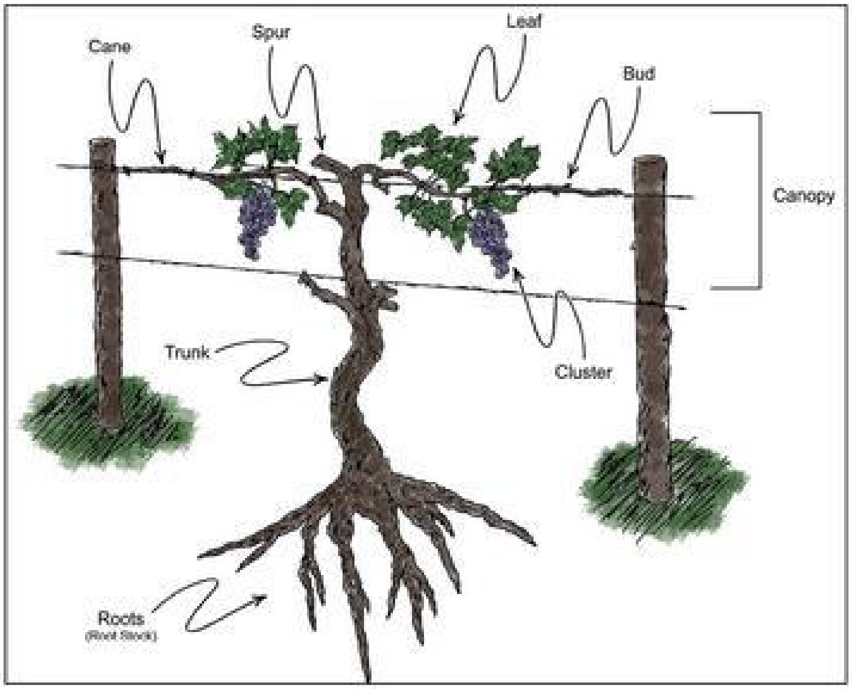

Figure 4–1: Parts of a grapevine

THE LIFE CYCLE

In nature, grapes propagate by producing seeds, but in commercial viticulture, this method is considered too unpredictable and tedious. A seed represents a genetically unique entity, drawing traits from both of its parents but with infinite, unpredictable variations possible. Furthermore, growing a plant from seed takes a long time and has a high failure rate.

One commercially viable method of grapevine propagation is cloning. The grower can choose a healthy grapevine that is known to have desirable characteristics, cut off a short length of a young cane, place it in water where it will start to grow roots, and then plant it in the vineyard. This new plant will be a *clone* of the vine from which it was cut, genetically identical, and with the same desirable characteristics. This method is more efficient than planting seeds and produces more consistent results.

An alternative to using rooted cuttings is *field grafting*. This is a method that may be used, for example, if there is an existing vineyard that is currently growing an undesired variety of grapes. As long as the vine's *rootstock* (the major root system) is healthy, the grower can remove its existing branches, make a small incision in the trunk, and insert an unrooted cutting from a desirable vine. The rootstock will heal at the wound site, and the cutting will begin to grow as if it had been planted in the ground, except that it will already have access to an extensive root network.

A newly planted or grafted vine will produce grapes during its first or second season, but these clusters of grapes are usually considered substandard in quality and removed in order to allow the vine to focus its energies on trunk and shoot development. The first crop of grapes to be used for wine is normally harvested in the third year, which is sometimes called "third leaf." While there is some debate about when a vine begins producing quality fruit, a common assertion is that it takes an average of six years before a grapevine develops to the point where its fruit is at its optimal quality level. It will then continue to produce its best grape crops for a decade or more.

After about twenty years, the vine becomes less vigorous, producing fewer grape clusters and fewer leaves. However, the *quality* of the grapes often continues to improve after vines are twenty years old, and grapes from these vines can be made into outstanding "old vine" wines. The term *old vine* is not widely regulated, but many vines given this designation are fifty years old or older. Some grapevines are still producing small amounts of quality grapes at more than a hundred years old.

THE ANNUAL GROWTH CYCLE

Winegrowing is most successful in temperate climates. Generally, the ideal regions fall between 30° and 50° latitude in both the Northern Hemisphere and the Southern Hemisphere, where the change of seasons brings long, warm-to-hot days in summer, and short, cool-to-cold days in winter.

The winter dormancy period, when the vines conserve their energy for the following spring, establishes an annual cycle of growth that culminates with the harvest of ripe grapes in the fall. It is important to remember, however, that the seasons are reversed between the Northern and Southern Hemispheres, so harvests in the two hemispheres take place roughly six months apart.

The cycle begins with the emergence of new greenery in the spring. The first sign of this process—which starts when the ground temperatures begin to rise above 50°F (10°C)—is *weeping*. Weeping occurs as the sap begins to flow upward from the trunk and out to the tips of the canes. This should only last a day or two, and soon thereafter, tiny shoots called buds emerge from the nodes in the vine’s branches. This is known as *bud break*, and it is the first critical event leading toward the success or failure of the year’s vintage. Bud break can be a hazardous time, especially in cooler climates, because the new growth is quite vulnerable to temperature extremes, and a late frost can do serious damage to the vines at this stage.

Figure 4–2: Bud break

As the shoots grow and strengthen, they begin to produce leaves. Until this point, the plant is drawing upon carbohydrate reserves stored in the vine from the previous year, and growth is slow. Once the leaves develop, however, photosynthesis can begin, and the plants can take in new energy directly from the sun and accelerate the pace of additional growth.

Flowering, the next critical phase, takes place 40 to 80 days after bud break. Clusters of tiny flowers appear at intervals along the shoots. Each flower that is fertilized will become the foundation for a grape. Vinifera grapevines are self-pollinating, so bees or other insects are not necessary for fertilization. Instead, the breeze blows the pollen from one part of the plant to another, or to neighboring vines, and the flower is fertilized to create a grape berry.

Warm, dry weather is ideal during flowering. Rainy or windy conditions at this time can prevent the pollen from reaching its destination within the flowers, resulting in fewer viable grapes and therefore a smaller crop. This transition from flower to berry (grapes are sometimes referred to as *berries*, especially when immature) is called *berry set* or *fruit set*.

A malady known as *coulure* ("shatter" in English) can cause poor fruit set, with many flowers failing to become fully developed berries. Another condition, *millerandage* (abnormal fruit set), sometimes caused by bad weather during flowering, results in grape bunches that have a high proportion of small seedless berries mixed in with the normal, larger, seed-bearing grapes.

After fruit set, the grape berries grow from tiny dots to their eventual mature size of approximately one-half to three-quarters of an inch in diameter over the next three months or so. They are initially small, hard, dull green in color, high in acid, and low in sugar. The berries grow slowly for about a month and a half, at which point a major change in their development takes place. This short but important event is known as *veraison*.

Veraison signals a sudden acceleration toward maturation. It is most noticeable in red grapes, which begin to take on color at this time. White grapes also change in appearance—often remaining green but becoming translucent—or transitioning to yellow or gold. After veraison, the grapes continue to mature, soften, and enlarge. Inside the berries, sugar is being stored, acidity levels are falling, and the seeds are developing.

Harvest generally takes place a month and a half to two months after veraison, when the grapes are ripe in terms of both sugar levels (*physical maturity*) and *phenolic maturity*. Phenolic maturity refers to the level and character of certain phenolic compounds in the grape, including tannins and other compounds that enhance the color, flavor, and aromas of the resulting wine. Sugar concentration and phenolic ripening occur together over the summer, but not necessarily at the same rate. Sometimes the grapes will develop an acceptable level of sugar before the flavors and phenolics—particularly color and tannins—fully emerge, while at other times the situation is reversed.

The time period from bud break to harvest is normally around 140 to 160 days; however, under certain circumstances it can be as short as 110 days or as long as 200 days.

The time period from bud break to harvest is normally around 140 to 160 days but can be as short as 110 days or as long as 200. Harvest begins in early fall with the earliest-ripening grape varieties in the warmest regions, and it may continue into late fall and even early winter in the coolest regions, where grapes need more time to fully ripen.

Cold nights in autumn signal the vine to go into a dormant state in order to protect itself from damage over the winter. The vine will drop its leaves and withdraw sap from the branches and shoots, moving it into the trunk and roots, where there is less likelihood of injury from freezing. Once the vine enters dormancy, growers will conduct winter pruning, removing most of the year's growth in an attempt to keep the vine at a manageable size and ensure an appropriate yield the following year.

Figure 4–3: Veraison

THE VINE'S METABOLIC PROCESSES

There are several fundamental processes of grapevine metabolism that have a direct impact on wine quality, and that should be understood by wine professionals. These include photosynthesis, respiration, transpiration, and translocation.

Photosynthesis: This is a process common to all green plants in which sunlight is used by the chlorophyll-containing (green) parts of a plant, primarily the leaves, to convert carbon dioxide and water into sugar. These sugars are the basic building blocks of most materials found in the vine. In grapevines and many other plants, some of this sugar is stored in the fruit. The rate of sugar production, and thus the rate at which the grapes are filled with sugar, is directly related to the amount of photosynthesis that takes place. Photosynthesis depends primarily on two things: sunshine and temperature.

Photosynthesis only occurs when the sun is shining, and it slows at temperatures less than 50°F (10°C) or greater than 95°F (35°C).

Optimal sugar production takes place on sunny days with temperatures between 70°F and 85°F (20–30°C).

Ideal conditions for photosynthesis during the growing season include the following:

- *Warm days:* Photosynthesis slows down both when it is very hot and when it is chilly or cold.
- *Long days:* As photosynthesis can only occur when the sun is shining, the more hours of daylight, the more sugar is produced. This is an advantage for locations farther from the equator, which have longer days during the summertime.
- *Clear days:* When clouds block the sun, less energy is available for photosynthesis. Some will still occur, but sugar production will be reduced. Hours of fog or overcast skies during the day mean less sugar.
- *Minimal shading:* If many of a vine's leaves are shaded by other leaves, they will conduct very little photosynthesis. In an overgrown, bushy grapevine, fewer than half of the leaves might actually be receiving direct sunlight; the leaves that are not in the sun are ineffective at performing photosynthesis.
- *Southern aspect (or northern aspect in the Southern Hemisphere):* If the ground on which the vineyard sits is on a hillside slope that faces the sun, the plants will receive more direct sunlight. This is particularly significant in regions far from the equator, where the sun's rays arrive at a lower angle.

Respiration: Respiration occurs as the plant breaks down sugar and related carbohydrates, releasing their energy for use by the plant for activities such as root and leaf growth. However, during veraison and at other times when sugar is unavailable, the vine shifts from metabolizing sugar to metabolizing malic acid (as well as trace amounts of other compounds) for energy. Early in their development, grapes are full of malic acid, but later on, as respiration starts to utilize this acid, the acid level in the grapes will be much lower. If the level drops too low, the wine's flavor may be affected, and other problems may develop.

Respiration is a continuous process that occurs throughout the growing season, but its rate is affected by temperature. For every 18°F increase in temperature, the rate of respiration doubles. The warmer it is, the faster the plant respires, and the quicker the acid level drops as the vine uses its acid for energy. For this reason, cool nights are usually beneficial for the ripening of grapes, as this will minimize the acid loss during a time when photosynthesis is not taking place.

Some of the world's premier winegrowing regions experience a large diurnal (daily) temperature range with warm-to-hot afternoons but cool-to-cold nights; such weather conditions allow for maximum photosynthesis and enable the grapes to retain sufficient natural acidity.

Based on these considerations, the best conditions for producing grapes that are rich in sugar and still maintain a significant amount of natural acidity are warm—but not hot—cloudless days and cool nights in a well-groomed vineyard that slopes downward, facing the sun.

Transpiration: Transpiration is the process by which water evaporates through openings on the underside of the leaves known as *stomata*. Transpiration is analogous to perspiration in animals and serves to cool the vine. The rate of transpiration is closely linked to the weather. It is highest under sunny, hot, windy, and dry conditions, and it is lowest under cloudy, cool, still, and humid conditions. The stomata will close if not enough water is brought in through the roots to meet the transpirational demand. Because these openings also control the intake of carbon dioxide, a shutdown of transpiration will also stop photosynthetic activity.

Translocation: A final metabolic process is translocation, the process by which materials are moved from one area of the plant to another. Sugars, for example, are moved from the leaves, where they are made, to the growing shoot tips, roots, or trunk, where they are needed for energy. Sugars not needed for energy may be directed to the grape clusters, or stored in the woody portions of the trunk and root system for future use.

TERROIR

Beyond grape variety and viticultural practices, the combined natural aspects of a vineyard, such as climate, soil, sunlight, and water, can have a major impact on the overall character and quality of a wine. The French term for this, *terroir*, has been adopted throughout the wine community. This section describes some of the elements that make up terroir.

CLIMATE AND WEATHER

There are several mechanisms by which weather affects viticulture, changing the way vines grow and grapes ripen. Weather is the most changeable and uncontrollable of the variables that go into making wine and is often the biggest factor that causes one vintage to be different from the next.

It is important to distinguish between climate and weather, as they are not the same thing. *Weather* is the actual meteorological conditions experienced, whereas *climate* is the historical average weather of a place. Climate is what is expected in the long term, and weather is what is forecast in the short term and is what actually occurs.

It is the annual differences in weather that cause the variations in grapes and wine from year to year. In a region with a dry climate, the odds are that, on any day randomly chosen in the future, it will not rain. However, every once in a while, rainy weather will develop. A vineyard site is selected based on its climate, but the weather may or may not cooperate in a particular year.

The term *climate* is a general one, and is often modified by the prefixes *macro-, meso-,* and *micro-*. *Macroclimate* refers to the conditions of the overall region, and is roughly synonymous with *climate*. For instance, the effects of the Cascade rain shadow on the Yakima Valley AVA is an example of macroclimate. The term *mesoclimate* refers to what happens to a specific portion of the region, such as an entire vineyard. For instance, the mesoclimate of the Copeland Vineyard, a warm region with as little as 6 inches (15 cm) of rainfall a year located within the Yakima Valley AVA, is greatly influenced by its location on a south-facing slope some 1,300 feet (400 m) above sea level. The term *microclimate* refers to the climate of a small portion of a vineyard, such as a few rows. Finally, the term *canopy microclimate* is used to refer to the environment within and directly surrounding a single vine's canopy (or, at most, a small section of a single row).

The distinction between micro- and mesoclimates is important because these small differences in climate can account for significant differences in the resulting fruit, despite the fact that the vines were grown within the same macroclimate.

Below are some of the climatic and weather features that have the greatest effect on viticulture.

TEMPERATURE

As described above, the temperature in a vineyard has a great effect on the sugar–acid balance in grapes and helps to determine the quality of the resulting wine. A poor sugar–acid balance is usually the result of high temperatures. The impact of cold temperatures can also be significant, for example, at the very beginning of the growing season, when a late frost can endanger young shoot growth, or late in the season, when an early frost can damage an unharvested crop. Temperatures in the winter dormancy period are not normally a concern, unless it gets cold enough to freeze the ground several feet down and cause winterkill. These parameters define the limits of viticulture between the equator and the poles.

PRECIPITATION

Vines need about 20–30 inches (51–76 cm) of water annually, which they can receive through rainfall, irrigation, or a combination of the two. As long as irrigation is not prohibited by regional wine law and water is available, vineyards do not require rain. Otherwise, a moderate amount of precipitation is needed during the growing season, as well as over the winter to replenish the groundwater. Rain is particularly unwelcome during harvest, when the water swells the berries and dilutes their sugar content. In some regions, hail is not unusual in the summer. Hail can wipe out an entire crop if it strikes a vineyard after veraison.

HUMIDITY

High humidity makes for perfect conditions for the growth of fungus and mold, which can degrade the quality of grapes and may create the need for fungicides.

FOG

Frequent fogs can be good or bad. They reduce temperatures and sunlight in the vineyard, which may be beneficial in hotter climates but is not useful in cooler ones. Fog also raises the humidity, but if it is burned off by the sun in the late morning, as is often the case, it is not harmful. In some cases, fog creates the ideal conditions for the development of the *Botrytis cinerea* fungus, which is desired for the production of certain dessert wines.

WIND

Wind can also have a favorable or negative effect on a vineyard. Wind can interfere with the flowering and pollination process, thereby impacting the vine's ability to develop healthy fruit. High winds anytime during the season can put significant strain on the vines, which is why windbreaks are used in some locations. In regions subject to high-velocity winds, such as southern France with its mistral winds, the winds dictate the methods for trellising and pruning. However, some wind can also be beneficial to a vineyard by reducing humidity and pest concerns.

SOIL

There are many different types of soil present in vineyards. Some examples include clay, chalk, sand, gravel, silt, slate, marl, loess, and limestone. Grapevines can grow in almost any of them. However, the world's greatest vineyard sites seem to have two things in common:

1. They are not very fertile. In fertile soil, a vine has the tendency to produce an overabundance of shoots and bunches, with sugar and flavor components divided among too many grapes. Theoretically, this can be controlled, but to do so requires considerable labor. Less fertile soils encourage the vine to produce less vegetation and fewer grapes. This is part of the reason why, historically, grapes for wine have been planted in sites that were not amenable to the cultivation of other food crops.
2. Their soils regulate the supply of water to the vine. Ideally, the soil should enable the roots to access water when needed but also ensure that excess water is drained away, so there are no extremes of too much or too little moisture.

These factors help explain why the best vineyard sites maintain consistent quality regardless of vintage year.

Some tasters believe that a soil's composition imparts its unique flavor characteristics to grapes and the wines made from them. For instance, it could be believed that grapes grown in chalky soil will yield a wine with a chalky character. However, there is as yet little scientific evidence to support this concept, and the topic remains a popular source of debate among wine enthusiasts.

A soil type is defined by the sizes of particles it contains and the composition of those particles. The particle sizes are as follows:

- *Clay:* very fine particles that fit together so tightly that water has difficulty passing through
- *Silt:* particles of intermediate size
- *Sand:* coarse particles with relatively little water-retention capability

- *Gravel:* larger pieces of solid inorganic matter; essentially, inert obstacles that roots must pass around, or sometimes through, to reach water and nutrients

Soil normally contains varying proportions of each of these particle sizes. The particles themselves may be composed of one or more minerals, such as quartz, feldspar, or calcium carbonate. Soil also contains organic matter made up of decomposed plant and animal materials. These materials provide most of the nutrients the grapevine needs for continued growth.

PHYSICAL GEOGRAPHY

There will always be innumerable elements related to a vineyard's physical location that cannot be exactly duplicated anywhere else: distance from the ocean, contour of the land, latitude, proximity to mountain ranges and rivers, and so on. These often subtle and sometimes invisible features are what make terroir such an enigmatic influence.

Some geographic factors include the following:

- *Latitude:* In general, a lower latitude (that is, one closer to the equator) translates into hotter climates. Higher latitudes benefit from longer summer days and cooler nights, but they have a shorter growing season and possibly dangerous frosts and freezes.
- *Elevation:* Compared to a valley floor vineyard, a vineyard at a higher elevation will be cooler and windier, and may have less fog. Higher altitudes experience larger diurnal temperature swings, which is a positive factor as long as the nights don't get too cold. Well above sea level, the sunlight is more intense, encouraging photosynthesis.
- *Topography:* The way the vineyard is contoured can have any number of effects. Hillside vineyards have fewer problems with frost, but they can be harder to work if they are steep. Tractors and mechanical harvesters can navigate flat tracts easily, but

flat bottomland is often overly fertile. Rolling topography can create a patchwork of low areas that collect too much water and higher areas that are always dry.

- *Aspect:* In the Northern Hemisphere, a vineyard on a slope that faces south gets the most sun, which is highly desirable in cool regions but not so desirable in hotter ones. In the Southern Hemisphere, the north-facing slopes get the most sun exposure.
- *Proximity to bodies of water:* Water tends to change temperature more slowly than soil. The larger the body of water, the more it resists change. For this reason, vineyards located close to water—rivers, lakes, and especially oceans—experience far less temperature variation than those without water's moderating influence. Their diurnal temperature range is less, summers are not as hot, and winters are milder compared to other vineyards at the same latitude but located farther from the water. Bodies of water also provide a source of humidity, which in different areas can mean morning or evening fogs, greater cloud cover, rain, or fungus-encouraging dampness.

These geographic factors combine to produce an incredible diversity of climates around the world, often changing perceptibly in the space of a few miles. Climatologists group these climates into broad categories, but the ones most applicable to wine regions are maritime, Mediterranean, and continental.

- *Maritime climates* are strongly influenced by an ocean and have high rainfall and mild temperatures overall.
- *Continental climates* are the opposite: found in areas far from oceanic effects, they have hotter summers and colder winters—sometimes extreme in both directions—and they may have less precipitation.
- *Mediterranean climates*, typically found within the temperate latitudes, are characterized by warm, dry summers, mild, wet winters, and low humidity. Mediterranean climate zones are associated with high-pressure atmospheric cells found over many of the world's large oceans that pull rain toward the

region during the winter while keeping the areas warm and dry during the summer.

Another term that is frequently heard in association with wine is "marginal climate," which refers to an area that has such cool temperatures or such a short summer growing season that grapes are just barely able to achieve enough ripeness for harvesting before autumn frosts arrive.

VINE DISEASES AND PESTS

DISEASES

Grapevine diseases may be caused by viruses, bacteria, or fungi. Different diseases attack different parts of the plant, such as roots, trunk, branches, shoots, flowers, or grapes, and are often most troublesome at a specific time of the year, such as during flowering or right before harvest. Some diseases result in a poor crop, while others threaten the survival of the vine itself.

Viral diseases can be spread by propagating infected vine cuttings, so controlling them is dependent upon avoiding introducing them to new vineyard plantings or grafted vines.

Bacterial diseases are more likely to be spread by insects and animals that carry the microbes. One example is Pierce's disease, a bacteriological contamination of the host vine resulting in premature leaf fall. This disease is spread by several types of sharpshooter insects, most notably the glassy-winged sharpshooter. These insects might feed on an infected vine and then transmit the bacteria to a healthy vine. Typically, these diseases are prevented through the systematic use of insecticides to control the carriers. However, new research has uncovered safe, organic remedies that may cure such diseases from within the plant.

Fungal diseases are generally spread by airborne spores and become a problem mostly in warm, humid conditions, which are ideal for the growth and spread of the fungus. Grape growers usually fight fungus with either sulfur or a commercial fungicide sprayed onto the vines. Two of the most damaging fungal diseases are powdery mildew, also known as *oidium*, and downy mildew, also known as *peronospora*.

Another significant fungus is *Botrytis cinerea*, which, uniquely, can be as beneficial as it can be harmful. When it is present at the wrong time or on grapes that are detrimentally affected by it, it is known as gray mold and wreaks havoc with the ripening grapes. However, when it develops on fully ripe grape varieties that can benefit from it (white grapes, especially Sémillon, Riesling, and Chenin Blanc), botrytis is known as noble rot. Botrytis is known to the French as *pourriture noble* and to the Germans as *Edelfäule*.

Figure 4–4: Grape clusters affected by Botrytis cinerea

Botrytis cinerea sends its filaments through the skin of the grape to tap into the juice. By extracting water from inside the berries, it concentrates the grapes' sugars and flavors while adding its own characteristic aroma, which has been described as being similar to honeysuckle. Botrytis develops best under very special climatic conditions: morning fog, which provides a humid environment that nurtures botrytis growth on the berries, followed by afternoon sun, which prevents the fungus from spreading over the entire vine. Under these conditions, botrytis is responsible for some of the finest sweet wines in the world.

PESTS

Grapevine pests come in many shapes and sizes, from microscopic insects to large mammals. Among the insects, the most serious is the tiny louse phylloxera. No other grapevine malady has caused such economic and viticultural damage.

Phylloxera—native to the eastern United States—was accidentally introduced to Europe in the mid-1800s, most likely brought in on the roots of samples or specimens of young vines of native North American origin. Once it became established, phylloxera devastated many of the established vineyards of Europe, spreading from vineyard to vineyard and country to country, killing off the vines on which it fed. The pest eventually made its way to other parts of the world—including Australia, New Zealand, South Africa, the west coast of the United States, and beyond—destroying many of the world's vinifera vines in its path.

Eventually, it was discovered that the native American grapevines had long ago developed a natural resistance to phylloxera. With this in mind, one early attempt at a solution in France was to interbreed native American vines and *Vitis vinifera* in order to develop hybrids that would have the varietal character of the vinifera and the disease resistance of the American species. Many of these hybrids were deemed unsatisfactory, however, so the practice did not gain widespread acceptance. It was ultimately discovered that the prized vinifera varieties could be grafted onto the rootstock of American vines with little, if any, degradation in the flavor profile of the vinifera fruit.

Cultivating grafted vines became standard procedure in most of the world's vineyards, and the destroyed vinifera vineyards in Europe and elsewhere were almost all replanted with grafted plants. This situation remains today, as no method of safely removing phylloxera from an active vineyard has been found. Only a few areas throughout the world can claim to be "phylloxera-free" to the extent that they can sustain ungrafted vines. Such regions are generally isolated from other wine regions, or they are rich in sandy soils that are inhospitable to this pest.

Another soil-based pest is the nematode. This microscopic roundworm also feeds on the vine's roots. In addition to causing direct damage to the vine via the worm's feeding, nematodes also transmit viruses that can kill the plant. This problem has become more prevalent with the increased use of shallow-rooted rootstocks and has been further compounded by the use of drip irrigation, which reduces the vine's tendency to send its roots deep into the soil in search of water. The most common solution to the problem is the use of nematode-resistant rootstocks, but certain cover crops, such as mustard, can act as a natural biofumigant.

By comparison, larger pests in the vineyard are more of a nuisance than a plague. Because the fruit is naturally sweet, many animals, including birds, deer, and wild pigs, like to snack on it. In some areas, this can cause significant economic losses, making it worth the expense to install fencing or netting to keep the animals away from the vines.

THE ROLE OF THE GRAPE GROWER

As is true of any grower regarding any agricultural crop, the grape grower's responsibility is to create the best possible growing conditions for the plants, free of competition from other vegetation, and with sufficient access to water and nutrients. The work of the grape grower often includes the following tasks.

PRUNING

Pruning, typically performed in the winter or early spring, involves removing much of the vegetative growth from the previous year as well as any excess foliage and branches. Pruning is necessary to manage the size, shape, and development of the vine.

Each of the vine's branches has several nodes that may produce a new shoot and, eventually, new fruit in the spring. However, the number of shoots and grape bunches that the plant would generate naturally is typically much higher than is desirable. The vine's roots can gather only a limited amount of nutrients, and uncontrolled leaf and fruit production would spread those nutrients too thinly. To produce quality wine grapes, the grower must remove all but a few of the nodes to allow the grapevine to focus its energies on supplying a small quantity of grape bunches with its entire output of sugar and nutrients.

Pruning is typically approached using one of the following general strategies:

- *Cane pruning:* Using cane pruning, the grower will remove all but one or two canes per vine. The remaining canes are attached to a horizontal trellis and trimmed so that each cane has between six and ten nodes (buds).
- *Spur (cordon) pruning:* Using spur pruning, vines are trained to develop one or more permanent cordons (branches), each of which will support several canes. Annual pruning will cut back the new canes, leaving behind several spurs. Each spur is a portion of a cane— measuring a few inches long—that contains several nodes (buds).

VINE TRAINING AND TRELLISING

Grape plants are climbing vines and will not naturally develop a trunk or central stalk for support, preferring instead to climb up and over nearby trees or other structures. As such, most commercial grapevines are attached to a vine training and trellis system that positions the vine as desired by the grower. The structure can be as simple as a single stake or as elaborate as a multilevel system of posts, crossbars, and wires. The goal in each case is to optimize the quality of the fruit by achieving a balance between the vigor of the vine and the desired yield of grapes per acre.

Trellised vines may utilize a simple vine training system—such as the *Guyot* system—in which one or two canes or cordons from each vine are trained along a wire. Such systems often use a configuration known as vertical shoot positioning (VSP) in which the new year's shoots and leave are trained upward and braced by trellis wires as they grow, with the grape bunches positioned below the leaves in the fruiting area. Benefits of vertical shoot positioning include good air circulation and light exposure as well as ease of use with mechanical harvesters.

In high vigor sites, a divided canopy—with two or more separate fruiting zones, spaced either horizontally or vertically—may be used to provide more space for the vine to spread out. Well-known examples of divided canopies include the Geneva Double Curtain, Lyre, and Scott Henry systems.

Figure 4–5: Bush vine Grenache

Some vines may develop a thick (and often somewhat gnarled) trunk over time. Often referred to as bush vines, head-trained, or *gobelet*-style vines, such vines are typically free-standing (without the need for a stake or other support) and spur pruned.

In the *pergola* system, overhead vines are trained up a tall support and then allowed to spread out horizontally, with the fruit hanging below.

CANOPY MANAGEMENT

Techniques that alter the position or number of shoots and grape clusters are collectively known as canopy management. Canopy management techniques employed during the growing season include shoot thinning, shoot positioning, leaf removal, crop thinning, and other procedures intended to optimize fruit quality through the control of vine yield and vigor.

IRRIGATION

In some regions, vines may require supplemental water as well as fertilizers or chemical nutrients to maintain their rate of growth. In some parts of Europe—particularly in those appellations that are highly regulated in many aspects of production—irrigation is either prohibited or tightly controlled. However, irrigation is used in many parts of the world and in some areas, commercial viticulture would be unsustainable without it.

MANAGING THE HARVEST

In the fall, the grower—often working in tandem with the winemaker—must decide upon the optimal time to harvest the grapes. This decision is based on the ripeness of the grapes and the style of wine to be produced as well as weather, labor availability, and economic considerations.

Figure 4–6: Refractometer in use

There are several different methods used to measure grape sugar concentration; most countries have their preferred scale and many use slightly different forms of analysis. In the United States, the concentration of sugar in the grapes is typically measured in *degrees Brix*. The most common tools used to measure grape sugar include a refractometer, and the more old-fashioned hydrometer. To estimate the potential ethanol level in a finished dry wine, the conversion factor is about 5/9, or 55%, of the Brix value. For example, grapes harvested at 24° Brix will yield a wine with an alcohol level of around 13.3% (24 × 0.55) if fermented dry. For a quick, rough estimate of potential alcohol, simply divide the Brix reading by two.

Other countries use different measurement systems to calculate the anticipated final alcohol level. Baumé, a unit of measurement used primarily in France, reflects the potential alcohol level in milliliters per 100 milliliters of wine. Freshly pressed grape juice with 12° Baumé will produce a wine with a maximum of 12% alcohol.

The system used in Germany and Switzerland, Oechsle, is a bit more complicated. To calculate it, measure the density of the grape must, subtract 1.0, and multiply this figure by 1,000. In other words: Oechsle = (density −1.0) × 1,000. Must with a density reading of 1.068 will have an Oechsle reading of 68, which is roughly 9% potential alcohol.

Table 4–1: Comparison of Sugar Measurement Systems

COMPARISON OF SUGAR MEASUREMENT SYSTEMS			
Potential Alcohol	US Brix (Bx)	FRANCE Baumé	GERMANY Oechsle (Oe)
12.0% abv	21.8°	12.0°	89
15.4% abv	28°	15.4°	110.4
16.0% abv	29.1°	16.0°	114.9

SPECIAL VITICULTURAL PRACTICES

ORGANIC VITICULTURE

Organic viticulture is grape growing without the use of manufactured fertilizers or pesticides. Recent focus on protecting the environment has created significant interest in organic agriculture; organic grapes represent one of the fastest-growing segments of viticulture today, and wines made from organic grapes are in great demand among consumers. (Note that there is a difference between organic grapes and organic wines, which will be discussed in chapter 5.)

To be recognized as an organic grower, it is necessary to go through a certification process overseen by an accredited body, such as a state agricultural department or a duly sanctioned private company.

In the United States, the US Department of Agriculture's (USDA) National Organic Program (NOP) designates the certifying bodies and provides the criteria that a vineyard must meet to be approved as organic. Other countries have their own certification procedures, but they are not currently recognized for wines imported into the United States.

The NOP maintains a list of banned chemicals, which includes most inorganic and manufactured chemicals. Some chemicals are allowed if there are no acceptable substitutes and if the chemical is generally recognized as safe. A vineyard must be free from all prohibited materials for a minimum of three years before it can become certified as organic.

To produce a quality crop without using synthetic chemicals, the grower must find alternative methods to promote growth and avoid pest and disease damage. For example, chemical fertilizers can be replaced with compost and manure. Rather than using herbicides to keep weeds down, additional mowing can be used to keep them under control. Various sulfur mixes, though inorganic, are allowed as effective fungicides. Natural predators and nonchemical solutions may be used to deal with pests.

INTEGRATED PEST MANAGEMENT (IPM)

Integrated Pest Management is a targeted approach to dealing with pests in a vineyard. Its goal is to eliminate or control only those insects that are actually present and causing damage, rather than applying a more general solution that kills all insects, as some may, in fact, be beneficial.

IPM employs a process in which each pest is considered individually, as directly and uniquely as possible. The life cycle of the pest, its natural predators, and its hosts are examined in order to find a particular vulnerability that can be exploited to kill or ward off the pest with the least amount of intervention and with minimal effect on the vines and the environment.

BIODYNAMIC VITICULTURE

Biodynamic viticulture is essentially organic viticulture with the addition of metaphysical elements and a few mandated procedures. Biodynamic viticulture is gaining in popularity among consumers, many of whom tend to think of it as "more organic than organic," although they may have only a hazy idea of how it differs from organic grape growing. Interpretations of the biodynamic philosophy vary among grape growers as well.

The philosophy of biodynamics, developed in the early twentieth century by Rudolf Steiner, is part of a larger movement that holds that all parts of the universe are interconnected as an ecosystem and that humans have the capacity to tap into the universal energy through meditation and mental practice. Proponents of biodynamic viticulture believe that the alignment of the planets and the phases of the moon should direct the course of work done in the vineyard and in the winery. In the biodynamic calendar, certain days are designated as fruit days, leaf days, flower days, or root days—each of which has its own ideal vineyard activities such as harvest, pruning, watering, or leaving the vines alone! There are nine special preparations that are fundamental to biodynamic viticulture, all compost mixtures that are thought to endow the organic fertilizer with spiritual energy. Certification as a biodynamic vineyard is available through a private organization known as Demeter International.

SUSTAINABLE VITICULTURE

Sustainable viticulture has the same goals as organic and biodynamic viticulture, with one major difference in approach: it abandons the black-and-white criteria of the organic philosophy for a grayscale of relative value in protecting the environment. As with organic farming, the intent is to leave the land for the next generation in better condition than it was when it was inherited by the current farmer. However, sustainability theory does not provide a set of rules about the correct path to follow in pursuit of that ideal. In addition, it includes an analysis of social goals and economic viability.

For example, neither organic nor biodynamic principles really address climate change and greenhouse gases, but sustainability does. A grower might decide that it is more environmentally sound overall and therefore more sustainable to use infrequent applications of a mild herbicide to control weeds rather than use a tractor to mow them under. Another example is water usage: organic practices do not address it, but sustainability recognizes that water is a scarce resource that must be used wisely.

Figure 4–7: Lodi Rules Sustainable Winegrowing Certified Green Seal

By using sustainable practices, a grower demonstrates a commitment to the long-term future of the environment, society, and winegrowing. Certification of sustainable practices is still in its infancy in the United States. However, regional efforts—such as the *Lodi Rules Sustainable Winegrowing Program* and the *Napa Green Certified Vineyard/Certified Winery programs*—are widely recognized and growing.