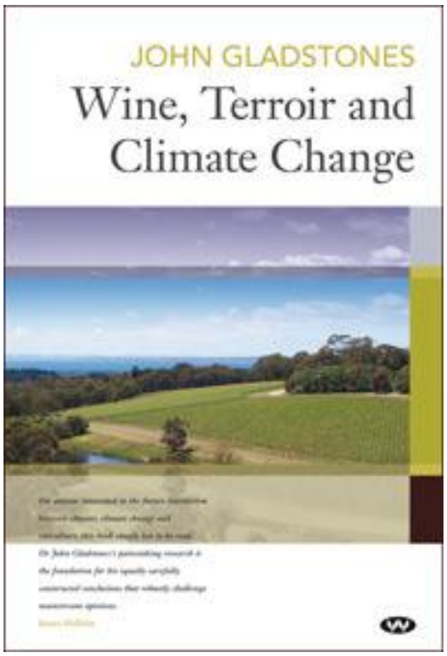
Light and Temperature



John Gladstones arrived on the viticultural scene in 1992 with his book *Viticulture and the Environment* which attempted to explain some of the complex relationships between the vine, wine quality and environmental conditions. This always held a fascination for me as I tend towards a systems approach to problem solving, in this case how to get a grape ripe. The berry is a little factory with all kinds of nifty manufactured products that accumulate or dissipate or both over the course of the vintage. As wine growers, we want to encourage and capture the good stuff that will make our wines taste, smell, look and feel better. If we can understand, quantify and organize the many contributors to wine quality there is a better chance to make consistently high quality wines. Gladstones first book left many important questions unanswered and now, almost 20 years later, there is a second book, *Wine, Terroir and Climate Change*, that tries very hard to fill in the gaps. It's what I have been waiting for.

I realize that most readers of this newsletter will probably not read the book so I'm going to try to offer a few highlights that may entice you to read further and deeper into these fascinating terroir relationships. I would encourage every grower to read this book and Markus Keller's *Science of the Grapevines.* If terroir is defined as the interaction of soil, climate, plant and viticulture then these two books, along with Robert White's *Soils for Fine Wine* and Tony Wolf's *Wine Production Guide for Eastern North America* pretty much cover the terroir spectrum for the inquisitive wine grower. There is an almost infinite distance between the words in a book and the reality of finding, developing and using a great wine site. While the complete answer to a what makes a great wine is not in these books, there is the foundation for understanding what you are looking for and why.

Great wine is always in search of great grapes. In my own confused mind, I have always figured that if growers could figure out how to consistently ripen their grapes to full maturity then fine wines would follow. Since the ripening process is a biological one, its mechanics are pretty much already set by nature and if we understood what these are we could try to find the conditions in which they most regularly exist. Gladstones helps us to understand and get closer to determining these ripening parameters and thus allow us to find the "sweet spot" where a particular variety will perform the best.
I should preface my remarks by explaining that I am way out of my league here, and prefer to leave the nuts and bolts of vine physiology to the likes of Markus Keller, Terry Bates, Tony Wolf and

others who understand the vine much better than I do. What I will try to do is to paraphrase Gladstones' remarkable first three chapters that focus on the effects of climate on the vine. The book also covers important viticultural topic such as soils, nutrition, vine balance, root function and more. I appreciate this book for its balance of the scientific and empirical, where both support each other to arrive at practical conclusions for the winegrower.

One of the main objectives of this book is to use environmental data as a tool to predict the development of the vine and, perhaps most importantly, harvest date. For practical purposes, however, I would much rather be informed about, and hopefully achieve, optimal growing conditions to nudge harvest earlier, than to know its approximate date. Given the tools that Gladstones provides and clever site selection and design, a vineyard can be developed that has the greatest opportunity to yield fully mature fruit, and hopefully the best possible wines.

Chapter 2 begins with this statement, "Temperature is central to all aspects of viticulture. The evidence is now clear that, with only minor other influences, it alone controls vine phenology, i.e. the vine's rate of physiological development through budbreak to flowering, setting, veraison and finally fruit ripeness." Since his first book, this reality has weighed very heavily on my mind, suggesting if we could find that range of optimal temperature we could more quickly and regularly ripen our grapes, not only to make the best wine but to harvest earlier and beat all the harvest threats (birds, deer, bees, disease, frost, hurricanes, rain, etc) to the punch. We know many of the aspects of site selection, vineyard design and viticulture management that will enhance fruit maturity, but in the final analysis, if temperature does not cooperate, the little chemical factory in the berry will not function at full production and leave the wine grower short of the critical compounds needed to make fine wines.

I have learned from Daniel Roberts of Integrated Winegrowing in California the importance of matching the right variety to temperature on a sites from Pinot Noir within view of the ocean on the Sonoma Coast to Cabernet Sauvignon at just the right elevation in the Mayacamas range on the west side of Napa to narrow the diurnal temperature shift into the optimal range to achieve optimal fruit maturity. Daniel understands the subtle benefit to wine from placing a grape in its optimal environment. I'm sure we need could achieve the same benefits in the Eastern U.S. if we put Gladstones to work.

The second natural element that comes into play is light, which is related to temperature (help! I never advanced past high school physics) and is responsible for photosynthesis, which creates the energy necessary to run the factories and, in the end, produce what matters to us - the alcohol that gives balance and texture to a wine. "Light interacts with temperature to govern photosynthesis, dry matter production and potential yield (via bud initiation)." As a wine grower, I tend not to fret over alcohol too much since careful chapitalization of wines is one of the least intrusive cellar interventions that can bring a wine into alcoholic balance, as has been done frequently in European wine regions prior to the recent effects of climate change. So as much as we tend to focus on brix as a parameter of ripeness, its importance is only that of a common indicator for other less well-defined criteria of fruit maturity (e.g. flavor, tannin, etc.). In this sceneario, temperature trumps light when it comes to wine.

In a bold statement Gladstones sets the optimal phenological development temperature cap at 19^{o}C, which is measured by production of new stem nodes and the periods between phenological stages (e.g. bud break, bloom, etc.). These processes are unrelated to photosynthesis and dry matter production in the vine. The response curve representing increasing temperature and rates of phenological development and dry matter production displays a steep increase in both with temperature until 19^{o}C is attained then phenologic development plateaus while dry matter continues up until it peaks at about 25^{o}C. As the season warms it is interesting to note that phenologic progress continues along the plateau as long as temperatures do not dip below 19^{o}C or exceed 40^{o}C. Development in the first two months and the date of bloom can usually forecast the dates of veraison and harvest that will follow later in the year. A fascinating study would compare the temperatures and phenological development in 2009 (late bud break, late harvest), 2010 (early bud break, early harvest), and 2011 (late bud break, and so far what appears to be an early harvest). In Gladstones model, seasons or regions with wide diurnal ranges are at a disadvantage for vine development since the cool nights would inhibit biochemical progress during these hours.

In international viticulture the common currency to describe varietal suitability within a temperature scheme is heat accumulation measured as growing degree days (GDD), a system for vines developed by Winkler and Amerine (1944) at UC Davis for California vineyard regions. However, it has its limitations as it uses 10^{o}C as the daily base, which disregards the influence of diurnal shift. As an improvement upon GDD, Gladstones proposes his biologically effective degree days or E^{o} days which accounts for GDD (base 10C), a diurnal range adjustment, and adjustment factors for site conditions such as air drainage, slope and latitude, soil properties, proximity to water, and wind (see Table 2.2, Page 15). These guidelines offered by Gladstones have much greater utility than simply adjusting E^{o} days, they offer insight and emphasis into site features that encourage phonologic and fruit development. Effective degree days is a much more complex system than the GDD we grew up with but it more accurately represents a site's conditions.

We are conditioned to believe that plants only grow during the day when the sun is out but that is not true. Depending on night temperatures, plants will continue to be actively growing. Dirunal temperature, or the difference between the high and low temperatures during a 24 hour period, greatly impacts vine physiology. Greenhouse experiments showed that optimal plant growth is achieved within a narrow diurnal range, and wide ranges retard development. In conditions of very cool night temperatures, phonologic development is severely restricted.

Diurnal temperature has always intrigued wine growers. The belief that the best wines are produced from wine areas with warm days and cool nights is deeply embedded among production professionals as well as the wine media and consumers. My curiosity has been that ever since his first book, Gladstones has offered that a narrow diurnal shift will promote ripening and, therefore, wine quality. When it comes to narrow diurnal range, the Mid-Atlantic is the champion. Often in summer and fall, diurnal change can be 5^{o}C or less. Think of a warm, humid August or September day when the high is 32^{o}C (90F) and the low 24^{o}C (75F). Under these conditions, the vine is still chugging away during the evening hours. Light is not involved, of course, so no photosynthetic activity is present, but the vine is still very active. So a vine may not be producing sugar (alcohol) but it is producing other essential compounds for wine. Gladstones argues that the narrow range allows these wine regions to produce balanced wines with lower alcohols. Cool nights in that are common in arid regions like California take vines out of the effective metabolic zone and slow the ripening process while pushing sugars during warm and sunny days, which also encourage loss of aroma and flavor components and pigments through evaporation and degradation.

I would not want to be the person to argue with wine quality in areas with different diurnal and environmental conditions, e.g. Bordeaux vs. Napa, Oregon vs. Burgundy, Germany vs. the Finger

Lakes, etc. In my experience, they simply produce a different style of wine. Any variability in quality is simply a matter of personal preference and taste. However, in our specific growing conditions in the Eastern U.S., understanding the effects of our unique diurnal patterns along with humidity and rainfall distribution is surely the path to producing more consistent and better wines, white and red, hybrid and *vinifera*, and everything in between.

Since humidity is such a strong presence during the growing season in the Eastern U.S. I was interested to know what Gladstones has to say about it. Low daily range sites tend to have higher humidity. His approach is to address the disadvantages of a warm and dry climate, in particular that solutes move in the phloem in response to evaporative draw from berry surfaces that can lead to excessive sugar and potassium, and the possibility of water stress. Most sites have raised humidity levels in the morning and it is in the afternoon that evaporative losses can be significant. As far as humidity correlates to rainfall, this can present a problem for humid sites.

Keller addresses humidity from the vapor pressure deficit perspective in that when VPD increases there is a stomatal response will be to restrict water loss via transpiration which will slow photosynthesis. Another impact of higher humidity is a tendency for vines to produce larger leaves due to ideal conditions for cell division and expansion. Large leaves, among winegrowers, are not considered desirable. Keller also notes increases in microclimate relative humidity up to 10%, which has implications, along with larger leaves, for fungal disease and shading problems.

Humid areas also tend to have more cloudy days. I have always wondered about the effects of cloudy and diffuse light on the efficiency of heat accumulation, biosynthesis, and photosynthesis. It is certainly possible to have warm <u>and</u> cloudy conditions in the Eastern U.S. Gladstones doesn't pull any punches when it comes to light, stating that, "A common New World assumption is that unlimited bright sunshine is beneficial for viticulture. Recent findings have challenged this idea. Temperate plants need only about a third of bright sunshine to photosynthesize at maximum rate. Too much light intensity, especially if accompanied by very high temperatures, may impede photosynthetic efficiency." It is possible for leaves to become assimilate saturated, causing them to stop photosynthesis when sufficient light is available. As I wrote in an earlier article when discussing the benefits of high tunnel light quality, diffuse, low or intermittent light can offer just as much photosynthetic benefit by allowing greater penetration of direct light to the interior of the canopy.

The effect of direct light and heat on temperatures around and within the berries can significantly affect metabolic processes. On a hot day it is possible for berry temperature to reach 12-15^{o}C above the ambient air temperature, causing evaporative and degradative loss of pigments and aromatic compounds and a slowing of their synthesis.

Early season temperatures determine the time of ripening but Gladstones highlights the 30 days prior to harvest as the most critical for development of grape and wine characteristics. This is the period of berry engustment and the creation of flavor and aroma compounds as well as the natural sugar and acid balance, tannin ripeness for red wines and, to some extent, the degradation of methoxypyrazines. During this period, excesses of temperature (hot or cold) and rainfall can significantly alter fruit quality.

Flavor and pigment development respond most readily to moderate temperatures, similar to or slightly below those necessary for optimal growth, 14^{o}C at the lower threshold and 26^{o}C at the upper with 20^oC as the sweet spot in-between. It might be said that this represents the Holy Grail for environmental conditions in the stretch run, the goal being to ripen the fruit as quickly and efficiently as possible with optimal flavor and aromatics and balanced acid and alcohol. These are a lot of variables to align and every wine grower knows it is almost impossible to get all of these development curves to intersect at an ideal date on the calendar. Gladstones hedges his comments a bit by saying, "a range of optimum temperatures can be discerned, depending on grape variety and suggested ripening period optima for other climatic elements. His Table 3.1 on page 36 offers the suggested optimal climate averages for the final 30 days for a variety of wine styles.

As they have in California, I conclude from this that wine growers in warmer areas, mostly below the Mason-Dixon line, need to look to the hills to achieve the most effect diurnal effect for wine quality. As cooling occurs with higher latitude and elevation, warmth may be sought to bring the diurnal range to optimal range, for example, in the "banana belt" on the south and east shore of Seneca Lake. Gladstones formulates the same adage that grapes favor a cool site in a warm region and vice versa.

How many wine growers think about the vine's root system when they consider the key components of fruit ripening? In another section of his book Gladstones wanders into the dark, subterranean world of vine roots and plant hormones. Citing research he is able to make a case for the stress hormone abscisic acid (ABA) as having a major influence on fruit ripening, either directly or through its antagonism to a group of auxin hormones produced by immature seeds. The degradation of these auxins may influence the length of lag phase and in turn influence the relative time of fruit ripening. Other plant hormones such as gibberlic acid and cytokinins also participate in plant growth and fruiting.

Relating to the accompanying article in this newsletter where Dr. Jim Wolpert discusses the finer points of vine balance, Gladstones weighs in with, "the necessary combination of vine carbohydrate economy, water relations and root hormone production for best wine quality can only be reliably attained where vine vigour is moderate; crop load is moderate for that vigour, so as not to detract from root health and growth; and compbined soil and atmospheric water relations conduce to moderate stress post-setting, then consistently mild to moderate stress through veraison and ripening. The ripening period also needs to have low enough evaporative demand for berry sugar accumulation not to outpace other ripening processes." This pretty much says it all. How, then, do we fit these principles into the context of our environment? Gladstones contrasts this view of viticulture with Richard Smart's assertion that under proper conditions bigger vines yield bigger crops of equal fruit quality. From my experience, there is a phenology-like curve that limits the ascent of quality with yields, but in most wine production applications, the Smart position can be applied successfully.

I am going to end my review of vine physiology here and note that the book has many more worthy topics including chapters on vine balance and management, vine nutrition, geology and soil type, organic and biodynamic viticulture, and very importantly, maturity rankings according to E^o days. The final portion of the book, which I have not yet read, is all the possible effects of climate change on wine growing around the world.

This book is extremely well cited but it covers a range of topics so complex that it is simply hard to accept every conclusion. It is clear that much more research is needed on these very complex relationships and matters of plant physiology. However, for my money it is as definitive a guide to wine terroir as I have yet encountered and there is perhaps no other person who could have pulled all of this material together. I would strongly encourage all wine growers with a curious nature about how the vine functions in its environment to read this book. It is certainly one of my all-time favorites.

In Pennsylvania and the Eastern U.S. our challenge is, as always, to take the principles outlined here and put them into an effective practice in our region, then to make wine and compare them to international counterparts who also adhere to Gladstones' judgment. We already have vineyards and wineries moving well along this path and it is really exciting to see and taste the results of their efforts.

Brian Croser, the respected wine grower from Australia and Oregon (Petaluma and Argyle) wrote an excellent review of Gladstones' book called *Croser on Gladstones*, dated 8/5/11. It can be found on Jancis Robinson's Purple Pages website at: http://www.jancisrobinson.com/.

Wine, Terroir and Climate Change: order it from Wakefield Press at
http://www.wakefieldpress.com.au/product.php?productid=878

Temperature conversion tool: http://www.onlineconversion.com/temperature.htm

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