PINOT NOIR: CRACKING THE CLONAL CODE

From Pommard to 777, a bewildering array of numbers and names are used to refer to the hundreds of different Pinot Noir clones used around the world. But how much do we really understand about their genetic identity, origins, and properties? Drawing on the latest academic and in-the-field research, **Anne Krebiehl MW** attempts to navigate the mire of confusion surrounding Pinot's clonal diversity

Drinkers and travelers in pursuit of Pinot Noir will inevitably hear talk of clones. Terms like "Pommard," "Wädenswil," and "Dijon" are thrown about with abandon and often mingle with numbers like 114 and 115, the palindromic 828, and the fervently evoked 777. I often wonder whether the latter's predominance in Pinotphile corners of the globe has more to do with an atavistic desire for a fateful, totemic, triple number bestowing Burgundian magic than with any actual viticultural characteristics. Depending on which part of the world you are in, countless names and numbers will crop up, spoken of in a way that sounds, at least to the casual listener, like something defined and definite. This is compounded by the entirely false assumption, repeated with sufficient frequency to become accepted as truth by many, that Pinot Noir is somehow more prone to mutation and less genetically stable than other *Vitis vinifera* varieties. Countering that, Robinson, Harding and Vouillamoz insist in their seminal reference work *Wine Grapes* that "Pinot has hundreds of clones simply because it is very old, not because it is naturally more prone to mutation than other varieties."[1] The picture that emerges of these "hundreds" of clones is a mire of confusion, dogged by hearsay, wishful thinking, and half-baked assumptions. A mere handful of Pinot Noir clones is currently fashionable, while a whole host of long-established clones supposedly constitute a "true, local clonal heritage." So, what is out there? What is the current state of development? Where will this journey take us?

All photography by Jon Wyand

Before trying to answer those questions, here are a few basics. Clonal selection is an asexual, vegetative propagation using genetically identical cuttings from one plant that has been observed and shows desired traits. Cuttings are taken, tested for disease, planted out, and observed. Their fruit is microvinified over a period of years. The process itself is very slow and, as Dr Richard Smart puts it, "requires considerable investment of resources, several years of records, followed by comparative trials."[2] It can take up to two decades to identify a viable, worthwhile clone. The aim of clonal selection is, thus, to have healthy, varietally true planting material with certain desired traits.

The earliest clonal selection of Pinot Noir?

While the origins of Pinot Noir are lost in the mists of time, the beginnings of clonal selection clearly have their root in necessity. Historically, vines were propagated by *provignage* (layering) or by taking ungrafted cuttings (specially selected or not) and planting these. Post-phylloxera, these practices became impossible, while grafting itself helped spread disease, resulting by the early to mid-20th century in virus-ravaged vineyards with unviably low yields.[3] There was therefore a compelling need for healthy single-varietal plant material that would ensure reliable and economically viable yields, not only for Pinot Noir. Clonal selection for vines has its origins in 19th-century Germany, where it became established by the 1920s,[4] just as in Switzerland where records show clonal selection trials for Chasselas as early as 1923.[5] Germany, where Pinot Noir has had a historic presence since the Middle Ages, may be responsible for the world's first official inquiry into clonal selection of Pinot Noir. A decree from the Ministry of Agriculture and Forestry in Berlin, dated February 23, 1927, sent to the Prussian state domains in the Rheingau, is astonishingly detailed: "The uncertainty in yield in terms of quantity and quality, the extent and persistence of vine disease, the related high production costs and economic difficulties of viticulture, pose an imperative demand [...] insistently to develop and pursue vine breeding. I therefore sincerely request that the state domains take measures, still within the year, to establish clones—ie, vegetatively propagated progeny of a single, parent vine. These clones are to be propagated separately according to the parent vine [...] avoiding massal selection."[6] While this project also included Riesling and Silvaner, there are detailed reports for the years 1928–31 for Pinot Noir specifically at Domäne Assmannshausen. Clonal selections of Pinot Noir were later conducted in Geisenheim, Weinsberg, and Freiburg, and a host of them was first registered in 1956, even though some were used before then. According to Dr Olivier Viret, product manager for viticulture and enology at Agroscope, the Swiss federal research institute, clonal selection of Pinot Noir at the research stations in Wädenswil and Changins, now subsumed into Agroscope, did not begin until the 1950s, but he does not rule out the possibility that commercial nurseries may well have made selections before then. France did not start official clonal selections for Pinot Noir until much later, even though vignerons and nurseries may have undertaken their own.

Above: Pinot Noir clones and rootstock clearly indicated at Iron Horse in Sonoma. Below: Budbreak in Pinot Noir, one of the many parameters influenced by clones.

Clonal selection in France

In *Le Livre du Pinot Noir*, Robert J Boidron, agronomist and ex-director of ENTAV-INRA, charts Pinot's history. He describes the incisive effect phylloxera had in Burgundy and notes the loss of "numerous varietal types" and the "disappearance of wild forms" of the vine through the devastation brought on first by downy and powdery mildew and then by phylloxera in the late 19th century: "All the Pinot vines having been annihilated (except in a few vineyards, such as La Romanée-Conti, which were treated with the insecticides of the time), it is impossible to know which the varietal types and 'local selections' were that could be saved and grafted before the complete decomposition of the vine [...]. We can imagine that the first replantings were made with grafted budwood the nurserymen could actually find, of *fin* vines but also of 'local selections'—those described in the early-20th-century ampelographies—which for the most part provided significantly higher yields than the Pinots 'fins' and 'très fins.' Let us not forget that production had collapsed and that the priority at the time was above all to produce." The phylloxera crisis, Boidron reminds us, brought "veritable upheaval" to viticulture. The advent of grafting on American rootstocks in 1887, he notes, increased vine vigor. Planting density went from 30,000–40,000 vines/ha to about 10,000, with Guyot-training facilitating cultivation by horse traction and average yields increasing. But Boidron also enumerates the difficulties of the early 20th century: the overproduction crisis that caused riots in the Midi and Champagne, with less dramatic effects in Burgundy; the economic crisis of the 1930s; and not least the effects of two world wars. On the positive side, he holds the valorization engendered by the 1935 appellation laws and the founding of the Confrèrie des Chevaliers de Tastevin (1934) and Saint Vincent Tournante (1938), "particular initiatives that helped relaunch the renown of the wines."[7]

Without sanitary controls, which did not exist when vineyards were replanted, virus spread—at first fanleaf, then leafroll.[8] This brought the "emergence of a new professional category: the *pépiniéristes*," or nurserymen, who were often wine growers themselves: "These played a definite role in the evolution of the types of seedlings offered to growers by generally orienting their choice toward the most productive, most 'beautiful' vines."[9] But Boidron also notes that some stuck to grafting their own vines, from their own material, as and when they needed. At first, he says, massal selection was used to ward off the effects of fanleaf by propagating only healthy-looking, vigorous, and well-bearing vines, but he concedes that the concomitant increases in yield became the real reason for massal selection. Interestingly, the first official clonal selection of Burgundian Pinot clones did not begin until 1960, when "INRA, via its plant pathology station in Colmar [...], obtained the first clonal selections of Pinot Noir from marked vines in a parcel of Morey-St-Denis belonging to the Domaine of JM Ponsot [...]. This resulted in the first approvals, based on sanitary criteria alone (absence of fanleaf, leafroll, and mottling), and the certification of the first clones of Pinot Noir in 1971." These were numbered 111 to 115. Laurent Ponsot, current guardian of the Domaine, says that the 1960 official selection was taken from vines planted in 1954 by his father and grandfather, stemming from "a very severe intelligent massal selection, probably selected in the late 1940s and early '50s, as they had their own nursery." The initial reasons for his predecessors' selections were sanitary, but, says Ponsot, "they had the idea overall to control yields in order to give to each plant the capacity to extract the essence of each terroir." Also in 1960, the Association Technique Viticole de Bourgogne (ATVB) was

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founded with Bernard Raymond as director; he continued the clonal selection work—hence the notion of "Bernard" clones. In 1962, a precursor to ENTAV was established to coordinate selections at national level.

Clonal explorations in America and New Zealand

Europe was not alone, however, in being plagued by virus disease; the need for sanitary planting material was a concern for viticulturists everywhere. UC Davis, under the auspices of Dr Harold Olmo, also moved to identify, clean up, and propagate clonal material from pre-Prohibition vineyards in the 1950s—that is, vineyards that had been planted to Pinot Noir and were not grubbed up during Prohibition, which ended in 1933. But as John Winthrop Haeger writes in his magisterial *North American Pinot Noir*, "Even as he carried on this work, the coincidence of viral infections and misidentifications seems to have convinced Olmo that a full palette of healthy, true-to-variety plants could not be constructed entirely from California's heritage vineyards."[10] UC Davis thus started instituting quarantines for new material, importing and heat-treating European clones. Susan Nelson-Kluk notes that one of Olmo's first two Pinot Noir imports in 1951 came from Pommard, predating the first official selections made in France and without further information on provenance, while the other, strangely, came from Spain. The first one became UCD4, and its heat-treated offspring became UCD 5 and 6, but all of them have since been struck off the register of authorized clones due to viral infection. The cleaned-up version is now known as FPS91. This group is still referred to in the US as the Pommard clones. So, when Americans casually refer to "Pommard," they may be referring to UCD 4, 5, 6, or even to 79. Imports continued, and in 1952 three clones from Wädenswil were imported.[11] Haeger notes a different attitude and suggests that Foundation Plant Services (FPS) and UC Davis at the time "were not especially interested in clonal selection" for distinct varietal traits but in "sanitary selection for disease freedom. In other words, a clone was a disease status, not a subvariety." Haeger also describes the continuing Californian imports and keen Oregonian interest in getting quality clones from France throughout the 1970s and '80s but notes the prevailing confusion: "Many selections, or combinations of selections, came to be known by the names of intermediaries, creating confusion that persists to this day."[12]

Events recorded by Dr Gerald Atkinson, director of Grapevine Research and Development, a division of North Canterbury Viticulture Limited, in a forensic account of Pinot Noir's presence in New Zealand, describe the tribulations of government viticulturist Frank Berrysmith at Te Kauwhata Research Station in sourcing healthy material: "In 1961—and throughout the 1960s, in fact—what confronted Berrysmith was

a very limited range of choices of virus-free vines [...]. [H]e quickly found that the Lausanne and Wädenswil stations in Switzerland and UC Davis were then the sole sources of putatively high health imports of the variety." Berrysmith's own propagation efforts were dogged by viral reinfection. Atkinson points out that "even up to 1980, all New Zealand's Pinot Noir imports (except for just two released in 1970 and 1979, respectively) continued to come solely from Switzerland or UC Davis." He is also aware of the confusion that surrounds the subject: "People don't necessarily know what's in the vineyard," he says. "They just slap a name on it that can gain some currency, and off goes the myth that they somehow have a new genetic line."[13]

Current selections

Back in Europe, Boidron reports that, "in Burgundy, field trials highlighted differences [...] between clones of Pinot Noir. Comparative tastings from mini-vinifications revealed significant qualitative differences, with equal or equivalent yield [...]. This result was not completely unexpected, but it was a revelation for some."[14] In Germany, the aims of clonal selection always mirrored the concerns of the age: "Unreliable, small crops initially focused research on ensuring yields [...]. [P]arameters of must weight, acidity, and colour did not gain importance until the 1950s, resulting in high-yielding, so-called 'standard' clones." It was the overriding problem of botrytis-susceptibility that first "focused research on selecting loose-clustered clones, delivering yields with lower rot-susceptibility. These were registered in the mid-'80s and early '90s." But the real breakthrough did not come until the millennium: "Desire for quality and lower yields focused on selection of loose, small-berried clones destined for premium production due to disease-resistance, aromatic and phenolic expression, good skin/pulp ratio, colour intensity, uniform ripening, and naturally reduced yields."[15] The two most successful of these new-generation clones are GM20-13 and FR18-01, not released for planting until 1999 and 2004 respectively, since when they have been enjoying great popularity, albeit almost exclusively in Germany.

France's ENTAV-INRA database currently lists 47 permitted clones, including those for sparkling wine. However, its dedicated Pinot Noir page advises that "conservatory collections set up in Alsace, Burgundy (Côte d'Or and Saône-et-Loire), and Champagne between 1971 and 1995 bring together nearly 800 clones." The oldest of these, including 114 and 115 (*see above*), were released in 1971; the famous 667 in 1980, and the even more famous 777 in 1981. While both are noted for "their good tannic structure," both also come with the additional comment: "appreciated for its agronomic characteristics, the quality and the color of the wines produced. Good aptitude for making wines with aging potential."[16] These were followed by 828 in 1985, and by 943 in 1989. The most recent are 1196 and 1197 in 2013, also noted for "structured wines with complex and distinctive Pinot Noir aromas, olfactory intensity, and tannin suppleness." Collectively—and confusingly—they are known as "Dijon clones." Interestingly, the database also notes the surface of propagating stock in nurseries: Most of the listed clones have less than one hectare (2.47 acres), whereas 777 has a striking 8.27ha (20.5 acres) of propagation stock, easily double that of the next most popular red-wine clone, 828, at 3.69ha (9 acres).[17] Clone 777 must be the world's most popular and successful Pinot Noir clone, with nurseries across the world licensed to import and propagate it.[18] But it may not always be the best suited to the climate: Ernst Rühl, head of grapevine breeding at Geisenheim University, says, "Botrytis bunch rot is a key issue in German Pinots. In most years, clones like 777 are a bunch-rot disaster [due to their tight bunch architecture]. With our new [loose-clustered] clones, we could drop the average proportion of botrytis-infected berries from approximately 35 percent in old clones, down to around 5 percent."

Brave New World?

But what about the famous Pinot Noir clones of the New World? These can be divided into two groups: vines brought as seedlings or cuttings in the 19th or early 20th centuries by settlers or immigrants trying to establish vineyards and a wine industry, and so-called gumboot or suitcase clones—mostly illegally imported cuttings, invariably taken from a famous Burgundy vineyard. The New Zealand clone known as Abel is definitely an example of the latter, smuggled into New Zealand in the late 1970s and intercepted by wine grower Malcolm Abel, who had to rely on a second income as a customs officer at Auckland airport. Rather than sending the offending cutting—said to be taken from La Tâche or another similarly famous vineyard—to the incinerator, he had it officially quarantined and propagated.[19] It is now a firm part of New Zealand Pinot culture. Atkinson says, "The right customs officer, at the right time, intercepts the right vine smuggler. But believe it or not, you're a bit of a sophisticate here if you grow it. It's a most unusual vine. It's a late ripener, ten days to two weeks later ripening than the Dijon clones, and it has that wonderful attribute that it keeps its pH down and holds its acidity—so it's a complete contrast to 777 and 115, for instance. It's quite spicy, it's not a black-fruited clone; it's dark, red cherry. It's very, very good, a real class act." Stories of such suitcase clones abound, but very few have been properly quarantined and propagated.

The most prevalent and prized Australian Pinot Noir clone falls into the first group of old and possibly pre-phylloxera material: MV6 (MV standing for mother vine) was selected by Graham Robert Gregory, deputy director general of agriculture in New South Wales, in the 1960s.[20] He took cuttings from the Mount Pleasant vineyard planted by Maurice O'Shea in 1923 in Pokolbin in the Hunter Valley, today owned by McWilliams, with material thought to be sourced from James Busby's 1832 consignment, its Pinot Noir cuttings said to stem from Clos Vougeot. Some Californian clones also fall into this first category, like the Jackson Clones or the Mount Eden Selections first identified by Olmo and Dr Austin Goheen in the 1950s and '60s and still available.[21]

These clones are often spoken of as "heritage" clones, implying that they represent forms of Pinot Noir that are by now, after more than 100 years, distinct from European material—again compounded by the erroneous belief in Pinot's inherent instability. Do scientists believe or know whether these clones have mutated since their arrival and thus become "true" Californian or Australian material? Dr Andy Walker, professor of viticulture and enology at UC Davis, is skeptical. "I would doubt that," he says. "I think that they were distinctive before they came here and doubt that they have changed or altered since then." Dr Gerald Atkinson in New Zealand, however, explains why it is so common that growers think they may have different material. It is due to the

well-known difference between genotype—that is, clone—and phenotype, the way the plant expresses its genes: "It is accepted now in genetics that there are epigenetic responses. One and the same clone in different vineyards will respond differently. One of the key differences you see is the hairiness and shape of the leaves of Pinot Noir in response to wind and cold. It's extremely responsive to vineyard environment, and we now know that this has a feedback effect on genetic switches. And Pinot is very prone to throwing up different phenotypes of the same genotype [or clone]. It will express itself differently in different vineyards; that is just the nature of the vine—it's very environment-sensitive. Take MV6 in Tasmania in a cool, windy vineyard, and in warm Hunter Valley: Assuming soil and irrigation are the same, it looks damn different and hasn't mutated," he explains. "This means that wherever you plant a certain clone with certain traits, it will still express itself differently. It also means that people might assume the different appearance was caused by a mutation and think they have a new clone, or they might think it is a different clone altogether. It goes quite some way to explaining the confusion that is out there. What you are likely to see is not genetic variation, but rather a variation in the way the vine expresses its genes."

Olivier Viret at Agroscope says, "Nobody can say whether it takes 10, 50, or 100 years until a vine spontaneously mutates, or what the parameters are that lead up to it. But it certainly is possible that within 100 years a mutation might have happened under these very different climatic conditions. But the big mystery remains why one plant would mutate in these conditions and another one next to it not." The only way to be sure would be new-generation sequencing of the genome to create a fingerprint of a clone, something that has only recently become possible and is still very expensive. Atkinson believes genetic fingerprints of clones are a distinct possibility for the future, if only to halt the widespread pirating of clonal material. On the possibility of distinct New World clones, he says, "The question is, What are you seeing? Anybody will accept that you see changes; you see that vines from the same source perform differently. What's going on? That's an interesting question. I wouldn't stick my neck out and claim that over, say, 150 years you can't say anymore that you have 777 planted, or Abel, or whatever. But what you can say is that there will be differences. They might be genuine shifts in the genome, or they may be differences in the way certain vines are responding to the environment; it could even be the feedback loop of epigenetics—that's an open question. The thesis is subversive."

Making evolution happen

Chris Winefield, senior lecturer in plant biochemistry and molecular biology at Lincoln University New Zealand, is nevertheless trying to create New Zealand clones of Pinot Noir. He explains his project: "There are elements in the genome that are mobile, bits of DNA that can copy themselves into new locations or, indeed, in some cases excise themselves from a particular location and reinsert themselves. We have resequenced the genomes from Pinot Noir, and we've seen that the differences between clones are predominantly driven by the biology of these mobile genetic elements called transposons. So, we started to think these mobile genetic elements are moving around the genome and are causing these random mutations. Can we take that into the laboratory, and could we use the natural biology and accelerate that so we can capture as many new genetic variances as possible?" The difference in

clones, claims Winefield, is down to "very subtle changes. While they have the same DNA, the arrangement of the DNA can be slightly different between clones. So, the differences in bunch architecture, in leaf shape that ampelographers have used to classify these clones, the changes in flavors and aromas—it's clear now that while they share maybe 99 percent of DNA, there is a certain portion of DNA that is different, that is being rearranged in a way that affects the way the plant grows and develops, but in a very subtle way. So, we have brought that back into the laboratory, where we have a degree of control over the process that allows these important differences to develop. We are basically looking to accelerate evolution. We take this material, which is not genetically modified, just take the naturally occurring changes and accelerate them very subtly. More important, we are using tissue cultures. What we end up doing is, rather than waiting for a random event on a vine, we are inducing mutations. Stress that the organism encounters in its environment has a number of obvious impacts in terms of its genetics, its biochemistry and its physiology. We put a grapevine under a particular stress—this might be heat stress or pathogen stress—and we see a number of changes going on. We see which genes are turned on and off to regulate the response to that stress. What we find is that we enhance the ability of these transposons to become active. How these interact, are shut down again, and alter the genes situated around them may yet explain elements of evolutionary science."

Assessment of these new "clones" is just beginning with planting out, so that plants can be observed and fruit microvinified. He expects a "small number" of these to be identified as new clones of Pinot Noir that are of use to the wine industry. But there also is inherent scientific value to his trials as "a very important research tool for the entire grapevine research community to start to take apart the biology of important characteristics of the grapevine, like flavor and aroma, bunch architecture, water-use efficiency—all of these things of which we have a certain degree of knowledge but really don't have the penetrating knowledge to understand which combinations of genes control those." But that is the future. Some suggest that all the diversity we may need of Pinot Noir is already here.

Preserving diversity

Concurrent to clonal selection for certain traits, there has also been a movement to use clonal selection in order to preserve biodiversity by selecting, virus-testing, and propagating well-performing clones from very old vines. Switzerland has formalized this into a national action plan for preservation, as Jean-Laurent Spring, of Agroscope, the Swiss Federal Research Station, explains: "The selection of vine clones is an approach frequently criticized of impoverishing the biodiversity of cultivated grape varieties, of promoting excessive production, of rendering the vine more sensitive to climatic hazards, and of reducing the complexity of wines produced. Sometimes these reproaches are justified, when a very limited choice of clones is multiplied massively for a given grape variety, as was the case in Switzerland in the 1970s and '80s for Chasselas or Pinot Noir. Viticultural research has long been aware of these dangers, however, and has integrated these into the selection of vines. This is particularly the case for projects to safeguard biodiversity and clonal selection of vines conducted by Agroscope.[22] Spring announced that three new clones—selected from ancient vineyards in central Valais—would be released in 2017. His colleague Olivier Viret says, "Today, the diversity we have is of immense interest. At Pully, we have at least 300 different clones, some of which have traits like sourness, that used to be frowned upon but are highly interesting now with climate change. It shows that clonal selection is a never-ending continuum but very expensive." It may thus be likely that the clones to be released in 2017 may have just such traits.

While clones alone do not hold the secret to a great wine, they are a fascinating link to the past and a continually adapting key to the future

Preservation was also the reason for Geisenheim's identification, clean-up, and registration of the Kastenholz clone in the Ahr Valley. It is amusing to think that the legend surrounding the arrival of this clone that apparently mutated to adapt to local conditions—allegedly obtained directly from Burgundy by medieval Benedictine monks at Kornelimünster Abbey and planted out near Castle Kastenholz—recalls the common Pinot-clone myth by claiming a direct link to a hallowed Burgundian vineyard.[23] Geisenheim's Ernst Rühl confirms that "our major aim over the past 30 years has been to preserve the genetic diversity in Pinot and expand the range of clones available to growers." He remarks, "We in Europe have access to genetic diversity resulting from 2,000 years of Pinot Noir cultivation." It is just a matter of "*suchen, finden, vermehren*" (seeking, finding, propagating). Laurent Audeguin, R&D director at the Institut Français de la Vigne et du Vin in Montpellier, agrees: "You know, what we mean by clonal selection is just trying to evaluate the natural diversity of a variety and to provide material for the wine industry that represents the natural variability and diversity. And there still is a lot of work to do, because there is huge natural and historic diversity." He, like his German and Swiss colleagues, says that the future aims of Pinot Noir selection may well include traits like later ripening and higher acidity. Atkinson is also convinced that the best is already out there—probably informed by his observations of the Abel clone: "What people fail to think about when they look at grand cru vineyards—where so much is about the soil, the site, the wonderful winemakers—is that they are looking at a different gene pool. That is what we need to investigate—it's an intensely, carefully managed gene pool that was the least ravaged by phylloxera."

Coming full circle

Evidently, the Burgundians themselves are thinking along the very same lines and founded the Association de la Sauvegarde des Cépages Bourguignons in 2008, prompted by a meeting in 2006 of Aubert de Villaine, of Domaine de Villaine and Domaine de la Romanée-Conti, and Denis Fetzman, a former director of Louis Latour. Boris Champy, the current technical director at Louis Latour, explains: "They, alongside others, expressed their fear of seeing old genetic material disappear." He says that they also agreed that the material from the official clonal programs was inferior to their own premier and grand cru material. "Many domaines had their own selection program, but everybody had some issues with virus recontamination and the stability of the selection," Champy explains. The privately funded association has illustrious members from around 40 domaines across the Côte d'Or. Champy says, "The objective was to select Pinot Fin, a type of Pinot with small cluster, dark berries, high quality, low yield, and to preserve the positive diversity with regard to disease resistance and acidity." The same process was started for Chardonnay two years later. Selections were made in vineyards planted before the 1960s and '70s, the heyday of clonal plantings, and between 500 and 600 *lignées*, or lineages, were planted—Champy says the association does not like the term "clone." "We were very humble in order not to repeat previous mistakes. Who would select high-sugar, low-acid, high-production vines today? We decided to preserve the diversity." Vines are observed and fruit is microvinified. The first *lignées* are expected to be ready for release in 2020. While the association is independent of ENTAV-INRA, for certification purposes it works closely with the Association Technique Viticole de Bourgogne, and France Agrimer.

Now that three European Pinot-clone powerhouses—in the shape of research institutes in France, Germany, and Switzerland—are each offering an array of clones for numerous conditions and purposes, as well as conservatory collections, and with further collections and trials held wherever Pinot Noir is grown, the diversity in this single variety is mind-boggling and well worth exploring. (The range is even wider when we include sparkling-wine clones.) When it comes to the terminology, though, we need to be cautious. Unless growers and wineries have kept scrupulous records of what they planted or where their cuttings came from, any clonal information they provide should be taken with a grain of salt. Almost all of the scientists interviewed here mentioned at some point the age-old interaction between humans and vines, a curious *pas de deux* between farmer and nature based, at least until now, solely on very close observation. While clones alone do not hold the secret to a great wine and constitute only one element among thousands in wine's almost infinite matrix of variables, they are a fascinating link to the past and a continually adapting key to the future. Clonal development, as Viret reminds us, is a continuum. Advances in deep genome sequencing might yet reveal more of Pinot Noir's secrets. But the ability to inspire an unending quest for the authentic and inviolable seems to be a vital part of Pinot Noir's DNA. ■

NOTES

1. Jancis Robinson, Julia Harding, and José Vouillamoz, *Wine Grapes* (Allen Lane, London; 2012), p.xv.
2. Jancis Robinson (ed), *The Oxford Companion to Wine* (4th edition, Oxford University Press, Oxford; 2015), p.190.
3. Robert J Boidron, *Le Livre du Pinot Noir* (Lavoissier, Paris 2016).
4. "Clonal selection in Germany began in the second half of the 19th century, when Gustav Froelich, a grape grower at Edenkoben in the Palatinate, selected single vines in a Silvaner vineyard, kept their progenies separate, and evaluated their performance in several stages (Schöffling and Stellmach, 1993). The joint ideas of some other breeders (Bauer, 1913; Ludowici, 1924; Seeliger, 1927; Baur, 1933) resulted in a triple-tier evaluation system with A, B, and C clones, typical for clonal selection in Germany today (Schöffling, 1984). This repeated testing led to high-performing uniform motherblocks and vineyards. A consequent selection for high performance also helped to reduce the incidence of viruses and virus-like diseases. Due to the positive results Froelich had achieved by clonal selection, this technique was taken up by German research stations and private breeders from the 1920s." Rühl, Konrad, Lindner, and Bleser, "Quality Criteria and Targets for Clonal Selection in Grapevines," International Symposium on Grapevine Growing, Commerce, and Research; ISHS *Acta Horticulturae* 652 (2003), p.29.
5. A Jaquinet, "Essai d'Appreciation de la Variabilité Genealogique d'un Clone de Chasselas" (1982), http://agris.fao.org/agris-search/search.do?recordID=IT19830938072
6. File II 2365 I (HHStAW, Division 454, No. 608). Hessisches Hauptstaatsarchiv Wiesbaden.
7. Boidron, *Le Livre du Pinot Noir*.
8. La Séction de Contrôle des Bois et Plants de Vigne was not created until 1948; Boidron, *Le Livre du Pinot Noir*.
9. Ibid.
10. John Winthrop Haeger, *North American Pinot Noir* (University of California Press, Oakland; 2004).
11. Susan Nelson-Kluk, "History of Pinot Noir at FPS," *FPS Grape Programme Newsletter*, October 2003. http://ngr.ucdavis.edu/cloneview.cfm?varietynum=3203. UCD4 was found to be virused but a cleaned-up version is now registered as FPS91.
12. In 1966, for instance, UC Davis imported two Swiss clones from Wädenswil from a selection first identified at the Mariafeld estate on Lake Zurich. When Americans today mention Wädenswil or Mariafeld, it is often unclear which of these clones they mean, or at which stage of their registration, since many were delisted and their cleaned-up offspring listed instead. This applies to both Oregon and California. Haeger, *North American Pinot Noir*.
13. Gerald Atkinson, "The Origins, History and Confusion of Pinot Noir Clone 10-5, Certain Pinot Droit and Other Pinot Noir Clones in New Zealand" (unpublished research paper; 2016).
14. Boidron, *Le Livre du Pinot Noir*.
15. Anne Krebiehl, "The Future of Premium German Pinot Noir," Institute of the Masters of Wine dissertation; 2012.
16. http://plantgrape.plantnet-project.org/fr/cepage/Pinot%20noir%20N
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