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Cabernet Sauvignon Vines Retain 400-Year-Old Epigenetic Signatures, UC Davis Study Finds

Research reveals grape’s molecular memory persists through centuries of clonal propagation, offering new insights for resilient crop breeding.

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Cabernet Sauvignon, the world’s most widely planted wine grape, has long been prized for its deep flavors and adaptability. Now, new research from the University of California, Davis, reveals that this grape variety still carries a molecular memory of its origins dating back nearly 400 years. The study, published in the journal Genome Biology, shows that cabernet sauvignon retains epigenetic marks—chemical switches that help control how genes turn on and off—from its parent varieties, cabernet franc and sauvignon blanc.

The story of cabernet sauvignon begins in 17th-century France, when a natural cross between cabernet franc and sauvignon blanc produced a new grape. Unlike annual crops such as corn or wheat, grapevines are propagated by cuttings rather than seeds. This means each new vine is essentially a clone of the original plant. As a result, every cabernet sauvignon vine growing today is almost genetically identical to that first hybrid.

Professor Dario Cantù of the UC Davis Department of Viticulture and Enology led the research team. He explained that most crops are improved over time through breeding, but grapevines are different. “We still cultivate plant material selected hundreds of years ago simply because cabernet sauvignon is so beloved,” Cantù said.

Scientists have long wondered whether epigenetic marks—modifications that do not change the DNA sequence but can influence gene activity—remain stable over centuries of clonal propagation. These marks can be inherited from parent plants or develop in response to environmental factors like stress or disease. Using advanced genome sequencing techniques, Cantù’s team found that these epigenetic signatures persist for centuries in clonally propagated crops like cabernet sauvignon.

To reach this conclusion, researchers created detailed genome maps of cabernet sauvignon and its parent grapes. They analyzed multiple clones of each variety and developed a new genomic model called a phased sequence graph. This model captures subtle genetic and epigenetic differences more accurately than traditional reference genomes. The team was able to trace how epigenetic marks are passed down along with DNA and how they affect gene activity.

The findings show that while individual vines may develop minor differences over time, their core epigenetic patterns remain remarkably stable. “It’s like sequencing identical twins at age 90 and still detecting the parental signatures they inherited,” Cantù said.

This discovery could have important implications for agriculture. Understanding which epigenetic responses to environmental stresses like heat or drought are stable could help scientists breed more resilient crops without changing their genetic makeup. Cantù suggested that if certain beneficial epigenetic changes persist over time, growers could expose vines to specific conditions to encourage those changes and select plants that retain them.

The research also highlights the historical connection between UC Davis and cabernet sauvignon. In 1997, UC Davis professor Carole Meredith identified cabernet franc and sauvignon blanc as the parents of cabernet sauvignon. Now, nearly three decades later, Cantù’s team has shown that the grape still bears molecular traces of its ancestry.

Other contributors to the study include Noé Cochetel, Amanda M. Vondras and Rosa Figueroa-Balderas from UC Davis; Joel Liou and Paul Peluso from Pacific Biosciences. The research received support from the National Science Foundation, the U.S. Department of Agriculture National Institute of Food and Agriculture, E. & J. Gallo Winery and the Ray Rossi Endowment in Viticulture and Enology.

The work opens new possibilities for understanding how long-lived crops adapt to their environments and how those adaptations might be preserved for future generations of growers and wine lovers around the world.