U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF VEGETABLE PATHOLOGY.
BULLETIN NO. 2.

THE CALIFORNIA VINE DISEASE.

A PRELIMINARY REPORT OF INVESTIGATIONS

BY

NEWTON B. PIERCE,
SPECIAL AGENT.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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NOTE.

The Division of Vegetable Pathology, formerly a section of the Botanical Division of this Department, became a distinct organization in July, 1890, and since that date has begun the issue of its own series of bulletins numbered independently. The following list, however, includes the publications of the Section prior to its reorganization as a Division, as well as those which have since been issued.

PUBLICATIONS OF THE DIVISION OF VEGETABLE PATHOLOGY.

Bulletins and circulars still on hand for distribution are designated by an asterisk (*). Bulletins 1, 2, 3, 4, and 6, omitted from the list, are publications of the Division of Botany, not relating to vegetable pathology.

JOURNALS.

Journal of Mycology, Vol. v, Nos. 1, 2, 3, and 4. 1889–'90, pp. 249, pl. 14. Vol. vi, Nos. 1, 2, 3, and 4.* 1890–'91, pp. 207, pl. 18. Vol. vii, No 1, 1891, pp. 63, pl. 10; No. 2*, pp. 65–194, pl. 7.

BULLETINS.

No. 2. Fungous Diseases of the Grape. 1886, pp. 136, pl. 7.
No. 5. Report on the Experiments made in 1887 in the Treatment of Downy Mildew, and Black Rot of the Grape. 1888, pp. 113.
No. 7.* Black Rot. 1888, pp. 29, pl. 1.
No. 8.* A Record of Some of the Work of the Division. 1889, pp. 69.
No. 9. Peach Yellows. 1889, pp. 254, pl. 36.
No. 10. Report on the Experiments made in 1888 in the Treatment of Downy Mildew, and Black Rot of the Grape, pp. 61.
No. 11. Report on the Experiments made in 1889 in the Treatment of Fungous Diseases of Plants. 1890, pp. 119.
Farmers' Bulletin No. 4. Fungous Diseases of the Grape and their Treatment. 1891, pp. 12.
No. 1.* Additional Evidence on the Communicability of Peach Yellows and Peach Rosette. 1891, pp. 65, pl. 39.
Farmers' Bulletin No. 5*. Treatment of Smuts of Oats and Wheat. 1892, pp. 8, pl. 1.
Farmers' Bulletin No. 7*. Spraying Fruits for Insect Pests and Fungous Diseases. pp. 20.

CIRCULARS.

No. 1. Treatment of Downy Mildew and Black Rot of the Grape. 1885, pp. 3.
No. 2. Grapevine Mildew and Black Rot. 1885, pp. 3.
No. 3. Treatment of Grape Rot and Mildew. 1886, pp. 2.

No. 4.* Treatment of the Potato and Tomato for Blight and Rot. 1886, pp. 3.
No. 5.* Fungicides or Remedies for Plant Diseases. 1888, pp. 10.
No. 6.* Treatment of Black Rot of the Grape. 1888, pp. 3.
No. 7.* Grapevine Diseases. 1889, pp. 4.
No. 8. Experiments in the Treatment of Pear Leaf-blight and Apple Powdery Mildew. pp. 11.
No. 9.* Root Rot of Cotton. 1889, pp. 4.
No. 10.* Treatment of Nursery Stock for Leaf-blight and Powdery Mildew. pp. 8.
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U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PATHOLOGY,
Washington, D. C., April 15, 1892.

SIR: I have the honor to transmit herewith a preliminary report on the California vine disease, by Mr. Newton B. Pierce, the special agent in charge of the work. The report covers the investigations made during a period of fifteen months, ten of which were spent in California and the rest abroad, mainly in France, Italy, and Northern Africa. The investigations abroad were carried on wholly at Mr. Pierce's expense, he at his own request being granted a leave of absence for six months without pay, in order that he might devote his entire attention to the work.

Respectfully,

B. T. GALLOWAY,
Chief of Division.

Hon. J. M. RUSK,
Secretary.

LETTER OF SUBMITTAL.

WASHINGTON, D. C., *June 15, 1891.*

SIR: In response to your request I have the honor to submit herewith a preliminary report of my investigations of the California vine disease. The report gives the main facts I have been able to gather relative to the subject during something over ten months of investigation in California, and is only intended to show the present condition of the work.

The number and diversity of the local conditions influencing this disease in southern California have added greatly to the difficulty of the investigation, and although continued effort has been used to avoid drawing incorrect conclusions, it is not improbable that mistakes have crept in that will require further investigation to correct. The work thus far has been done largely in the field, extended laboratory investigations having been impossible, owing to lack of time.

The difficulty of obtaining satisfactory information respecting certain vine diseases of the Mediterranean region which resemble the California malady showed the necessity of a comparative study of the diseases of that region. As the law does not provide for such work in foreign countries, I undertook the work at my own expense. The results have shown the action to be fully justified, not alone from the comparisons it has enabled me to make, but in the aid which the knowledge of the affinities of this disease will render in the investigations to follow. This foreign work was done in France, Italy, Sicily, and Algeria, and in preparing this report my foreign notes have been freely drawn upon whenever they seemed to make the subject clearer.

Although few lines of an investigation like this should be entirely lost sight of before absolute results are attained, yet I can say with confidence that several lines of inquiry at first important have been practically closed, others are nearly closed, and the still promising lines for investigation stand out more clearly than at first and will be carefully pursued.

I take this opportunity to acknowledge my obligations to the many vine-growers and other residents of California who have given information freely and who have aided me in such other ways as lay in their power. My thanks are also due to the officials of the California Central Railway system, who generously aided me in the field work done along their road. It is with pleasure, also, that I acknowledge

obligations to prominent scientists of France and Italy, who have assisted me in many ways. Among them special thanks are due to Dr. Foëx and Dr. Rabot, of the National School of Agriculture at Montpellier, France; M. Grasset, of Montblanc; Profs. Millardet, Gayon, and others, of the Faculty of Sciences at Bordeaux; Dr. Penzig, at Genoa, Italy; Dr. Briosi and Dr. Cavara, of the cryptogamic laboratory at Pavia; Profs. Cugini and Mori, of the cryptogamic laboratory at Modena; Dr. Targioni-Tozzetti, of Florence; Prof. Cuboni and his assistant, at the cryptogamic laboratory at Rome; Drs. Giglioli, Comes, Savastano, and Mottareale, of the Royal High School of Agriculture at Portici; Prof. Aloi and his assistant, and Mr. Charles Beek, of Catania, Sicily. I have also received courtesies from our Government representatives abroad, especially those at Bordeaux, Genoa, Rome, Florence, Naples, and Marsala.

Respectfully,

NEWTON B. PIERCE,
Special Agent.

B. T. GALLOWAY,
Chief of the Division of Vegetable Pathology.

THE CALIFORNIA VINE DISEASE.

By Newton B. Pierce.

CHAPTER I.

THE SITUATION AND PROSPECTS.

NATIONAL IMPORTANCE OF CALIFORNIA VINEYARDS.

The vine interests of California are of greater national than local importance. Locally nearly all horticultural interests are large, and the State, though deriving a liberal return from the grape, is not dependent upon it. On the other hand, the entire country is at present almost wholly dependent on California for domestic raisins and wines of the better class. The future will hardly change these relations, for the requirements of the country as a whole will increase more rapidly than the vine industry can extend into Arizona or other regions capable of supplementing California in the production of these commodities. A failure in the crop of Lockport apples may send the buyer to Michigan or Missouri. If the Indian River orange crop fails, the crop of Riverside Navels may still take its place. If yellows reduces the peach crop of Delaware, the yellows law of Michigan has saved the crop of the "fruit belt;" or if frost nips the Michigan buds, Missouri may still yield a crop, and California will send her train-loads of canned goods to the East. But should some disease destroy the grape crop of California every State in the Union would be forced to send money to foreign countries for raisins and fine brands of wine. It is for this reason that the vine interests of California are of special and unmistakable national importance, and too much can not be done to guard and stimulate the industry.

In 1890, according to returns given in the bulletin of the Census Office for March 10, 1891,[1] California had only 175 acres of vines less than all the other States and Territories of the Union combined. Hence any disease which threatens California vineyards endangers the better half of the vine industry of the United States.

[1] Census Bulletin No. 38, Washington, D. C., March 10, 1891. Viticulture. Statistics of grape-growing and wine production in the United States, by H. Gardner.

The vineyards of California are stated in the bulletin above cited to contain over 200,000 acres. The value of the entire plant is $86,640,350. It gives labor to over 100,000 employees. The total number of persons directly or indirectly dependent upon the industry can not well be estimated, but it is very large.

SUPPLY AND DEMAND OF VINEYARD PRODUCTS.

The requirements of the United States for raisins and for wine are in advance of the amount which California can at present produce. This is more especially true of the demand for raisins. The raisin crop of 1890 is given as 27,443,900 pounds. The imports for the year ending June 30, 1890, are given in the report of the Treasury Department as 36,914,330 pounds. The present demand for raisins, therefore, is more than double the home supply. This is not the limit of the growth of this industry, for the consumption per capita of raisins in the United States is much below the amount liable to be consumed in the future; and an immediate and abundant supply of this healthful product will result in a large increase in consumption. The increase of population will constantly call for an increased production; and it may be said that the demands of the country are much in excess of the domestic supply, and that the acreage of raisin grapes might be largely increased with safety. This does not take into account our growing ability to compete for trade in Canadian or other foreign markets.

The wine supply of the United States is more nearly equal to the demand than is the supply of raisins. About 4,500,000 gallons of wine and its products were imported in 1890, while the Californian output was 14,626,000 gallons. The importation should be largely cut off in the future by the Californian product. It is also probable that the increase in the wine trade due to the normal growth in consumption will more and more gravitate to California for the better class of wines, rather than remain in the East, where only native grapes are grown, or go to foreign vine-growers. At present between 9,000,000 and 10,000,000 gallons of wine are produced from the American varieties of grapes.

The market for Californian-grown table grapes is large and is capable of great expansion. The total crop of table grapes in the United States for 1890 was over 267,000 tons, of which only 38,785 tons were produced in California. It can hardly be questioned that much more of this total consumption will eventually be supplied by California vine-growers. Importations will also be largely replaced with California-grown fruit.

POSSIBILITIES OF THE INDUSTRY.

There are 20,000,000 to 23,000,000 acres of tillable land in the State of California. Hyatt says[1] there are in California more than 10,000,000 acres of the choicest grape lands in the world. Although this may be

[1] Introduction to Handbook of Grape Culture.

an overestimate, it is a fact that there are millions of acres in that State which are equal or superior to the majority of grape lands of Europe. Thus the extension of grape culture is in no danger of being hampered by the lack of suitable land. The mountain chains and the seacoast and inland valleys furnish all the situations that may be desired. The better the judgment of the prospective vine-grower, the better will be the location of his vineyard, as all kinds of locations are still available. Artesian land is abundant; irrigated ground of all classes may be had, and perhaps nowhere else in the world can be found a greater variety of soils or climatic conditions.

THE EFFECTS OF THE DISEASE.

Among the choicest and earliest vine-growing regions of California are the lands lying south of the San Bernardino Mountains. The northern part of the region, near the sea and reaching inland along the mountains, and included in the present counties of Los Angeles, San Bernardino, and Orange, is where the vine disease has been worst. Much of this region was devoted to vine-growing before the appearance of the disease. The wine grapes predominated, but many thousands of acres of the most thrifty raisin grapes were in bearing. These vines, mainly of the Muscat of Alexandria variety, were mostly located in the Santa Ana Valley, south of the region afterward affected, and largely in what is now Orange County. The vines about Anaheim were principally of the Mission variety, and among the oldest in the Santa Ana Valley. Toward Los Angeles there were many raisin vineyards, but the majority were of wine grapes. Eastward, in the San Gabriel Valley, the vineyards were principally of wine grapes.

The destruction of the vineyards by the disease has been more complete in the Santa Ana Valley than in the vicinity of Riverside and San Bernardino. The death of the vines near Los Angeles is nearly as complete as at Norwalk and other sandy regions southeast, although this occurred at a late date.

The direct and indirect losses arising from this disease are difficult to estimate, but they are very great. Mr. W. G. McPherson, of Orange County, has been the assessor in that region for many years, and is well informed in regard to the value of real estate through much of the vine-growing region of Los Angeles and Orange counties. In answer to a request for estimates of losses due to this disease he says:

In our neighborhood east of the Santa Ana River (Orange County) it was estimated five years ago that there were 10,000 acres of vines.[1] They were worth from $300 to $500 per acre. [The same land is now not worth more than $75 to $200 per acre.] My own place I could have sold easily for $500 per acre. Now I can not sell for $150 per acre. I estimate the direct loss [east of the Santa Ana River] at $2,000,000. Land

[1] The vines of these once fine vineyards are now almost wholly dead. Millions of them throughout the Santa Ana Valley have been removed from the ground and consumed as fuel.—N. B. P.

not planted in vineyards, as well as town property, has depreciated largely in consequence of the vines dying. Business men feel the loss in the way of less business nearly as much as the vineyardists. Then the trays, sweat boxes, machinery, and buildings gone to waste and disuse would amount to quite a sum; in fact, I should estimate the indirect loss at nearly another $1,000,000.

As we cross to the west side of the Santa Ana River as far as Compton and Los Angeles, then east again through the San Gabriel Valley as far as Pomona, the vines are nearly all dead, swelling the loss to at least $10,000,000.

These estimates are certainly not overdrawn. The vines now incurably diseased, including those already dead, will amount to over 20,000 acres; probably to over 25,000 acres. What the future spread of the disease may be is yet in doubt.

Besides the first loss on vineyards killed by this disease, the affected region sustains a large subsequent loss. This arises from the disuse of land occupied by the dying vines, the product of which would have brought into the country a gross receipt of many millions of dollars since the appearance of the disease. The loss to Los Angeles, Orange, and San Bernardino counties through the delay or stoppage of many improvements of various classes is also considerable.

CHAPTER II.

ORIGIN AND GROWTH OF THE EARLY VINE INDUSTRY OF SOUTHERN CALIFORNIA.

During the progress of the field work it became desirable to obtain information relative to the introduction and past history of the Mission vine. This information was mainly desired to ascertain if in the past any outbreaks of disease similar to the present had been noticed and recorded or whether we had to deal with a new feature of diseased vines. With the view of obtaining the desired facts from the missions where the vine had been longest cultivated, a request was sent to each of the present and former missions of the State asking for information relative to the origin, introduction, cultivation, and distribution of the old Mission vine. Only a few replies were received to these inquiries, the reason manifestly being the paucity of facts obtainable from the records of the missions.

The inability to procure the needed facts directly from the missions necessitated a study of the literature of the subject. This study has developed the facts and views given in the following pages, and although the history is by no means complete and may contain errors, it is, perhaps, worthy of a place here, especially when we consider that the old Mission vine is gradually being superseded by its more favored European rivals.

NOTES ON VINE-GROWING IN MEXICO.

As early as 1524 Cortez, who was then governor, saw the necessity for the advancement of agriculture in Mexico, the New Spain. Among other ordinances issued by him was one tending to this end. It appeared on March 20, 1524, and provided that all holders of repartimientos should yearly plant for every hundred Indians "one thousand vine shoots or other useful plants of the best kind, in the best location, and at the fittest time, until for every hundred of such Indians there should be five thousand plants well placed. The planting of Spanish products was especially enjoined."[1] He also requested that "all vessels for New Spain should be made to bring a number of seeds and plants wherewith to enrich the native varieties. This was, to a certain extent, complied with."[2] Hence "early experiments were made in the cultivation of silk, olives, and the grape, * * * but the cultivation of olives and the vine labored under severe restrictions."[3]

[1] History of Mexico, by H. H. Bancroft. San Francisco, 1883, vol. II, pp. 131, 132.
[2] *Ibid.*, p. 133.
[3] *Ibid.*, vol. III, p. 613.

The Mother Country soon became jealous of the growth of agriculture in her colonies and threw obstructions in the way of its development. It even went so far as to forbid the replacing of vines dying from age. Wine-making was heavily taxed and the industry discouraged. Under these circumstances the vine would perhaps have died out entirely had it not been for the protection of the Church, for at the convents and the churches the laws were not complied with.

This explains why the vine and the olive became the special property of the Church and the missions in later days, and why they happened to have charge of its introduction and spread in new regions. The decrees against the spread of the vine in the colonies, promulgated for upwards of two centuries, undoubtedly gave rise to a habit of reticence among those who retained and prized the plant; and it is probably for reasons of this kind that we find so few published records of its presence and spread among the missions and that information must be drawn from the observations of foreigners or from the journals of the courts.

It was not until long after the introduction of the vine into California that a more liberal policy was adopted toward the colonies. The resetting of vines had been forbidden since 1595, a period of more than one hundred and fifty years, the viceroys having been "repeatedly instructed not to permit the planting of new cuttings."[1] Hence it is not at all strange that no more perfect records respecting its introduction into California are obtainable. In 1811 Humboldt wrote:

> The court of Madrid has always viewed with an evil eye the culture of the olive, of the mulberry tree, of hemp, of flax, and of the vine in the new continent. If in Chile and Peru they have tolerated the trade in wines and indigenous oils it is only because these colonies, situated beyond Cape Horn, are frequently poorly supplied by Europe, and that they feared the effects of vexatious measures in provinces so far removed. The most odious systems of prohibition have been followed with tenacity in all the colonies the coasts of which are washed by the Atlantic Ocean. The viceroy, during my sojourn in Mexico, received the order of the court to remove the vines (*Arrancar las cepas*) in the northern provinces of Mexico because the commerce of Cadiz complains of a diminution in the consumption of the wines of Spain. Fortunately this order, like many others given by the ministers, has not been executed. They feel that, in spite of the extreme patience of the Mexican people, it may be dangerous to reduce them to despair by destroying their property and in forcing them to buy from the monopolists of Europe that which beneficent nature produced upon the Mexican soil.[2]

Only a few years after Cortez had ordered the planting of the vine the Mother Country began to awaken to the danger of losing its wine trade through the taxation, by Mexico, of the merchants who brought wine and other articles from Spain and the islands. The Emperor of Spain in 1538 and again in 1633 framed a law as follows:

> The viceroys and justices of the Indies are instructed not to allow taxes to be levied on merchants of these kingdoms and adjacent islands who bring wines, meals,

[1] History of Mexico, by H. H. Bancroft. San Francisco, 1883, vol. III, p. 613.

[2] Voyage de Humboldt et Bonpland. Essai politique. Paris, 1811, tome ii, pp. 415, 416.

and other supplies in order that they may with our consent sell them less or more as they can; but let the taxes be imposed on the hucksters, who buy to sell again, taking in consideration the price they paid, according to the judgment of the governors and justices.[1]

Although Spain was mostly able to control the market of Mexico proper, the vine industry of Peru was steadily growing, and the inhabitants began to seek a market for their surplus wines. In 1586, under a law of Don Philip II, we find Spain legislating against the sale of Peruvian wines at foreign ports. This law is as follows:

We order that in the city of Panama, or in any place confined within its district, no tavern-keeper, grocer, or other individual whatever be allowed to sell or do sell privately or publicly any fermented wine; and all the wine sold in the taverns and groceries must be from these kingdoms, without commixture of boiled wine, under fine of $50 in gold for the first time it was sold in greater or less quantity (and the wine shall be lost, and the entire amount must be divided into three shares, one for the public works, another for the judge, the last for the informer), and for the second time the law is violated the fine must be doubled and the infringer banished from the Kingdom; * * * and if any negro man or woman, free or slave, shall commit this offense the punishment will always be doubled, and the culprit will receive two hundred lashes in the public streets.[2]

In 1595 Spain ordered that "the Indians in the inns be provided with rations of bread, wine, meat, and corn." Wine must be sold, but it must not be brought elsewhere than from Spain. The following law, though probably tempered somewhat by the fear that they might overstep themselves in a region as far off as Peru, is still a good example of what Spain wished for all her colonies.

By our instructions to viceroys, other schedules and writs, it is forbidden to plant vineyards in the Indies, and the viceroys are ordered to refuse the license of planting new ones or to repair those already laid waste. Citizens and inhabitants of Peru having, contrary to our decrees, planted many vineyards and usurped the grounds in which they planted them, we, willing to show our clemency and benignity, do order and exact that all the owners and holders of vines give us and pay us, every year, at the rate of 2 per cent of all their vine fruit; and in order to fix this matter in the most proper way they will all submit themselves to the deeds of the census made in behalf of our royal estate and patrimony and necessary for the yearly payment of the said 2 per cent of their vine fruit, and that these deeds be delivered to the royal officials of the district in which the vines are situated, these men being very careful to recover all that this is worth, for us; and, the deeds being made, the viceroys, presidents, and governors will give in our name to the holders and owners the suitable information in order that without delay they may keep, possess, enjoy, and repair those vineyards and transmit them to their heirs and successors or anyone who should have a title or a court decision in his behalf, and quietly and peaceably forgiving all and remitting whatever punishment has been incurred for that motive, with this condition: that as to setting new ones again, the old ordinances, schedules, instruction, and decrees forbidding such a thing shall be enforced.[3]

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[1] The Emperor Don Carlos and the Empress G., in Valladolid, April 8, 1538. Don Philip IV, in Madrid, June 22, 1633.

[2] Don Philip II, in St. Lorenzo, September 16, 1586.

[3] Don Philip II: Instructions to Viceroys, 1595, chap. 40. Don Philip III: Aranda, August 14, 1610. Don Philip IV: Instructions of 1628, chap. 40; and Madrid, May 27, 1631.

Besides this direct legislation, the indirect form became stronger and more marked as time advanced. In 1614 some strong efforts were made to exclude Peruvian wines from Panama. The court says:

We order that no person of any condition or rank be allowed to import into the city of Panama whatsoever kind of Peruvian wine, either openly or secretly, nor to land it ashore or sell it in storerooms under pretense of having brought it for personal use or beverage or for the use of the marine crews, or under any other excuse, with the sanction of losing the wine, which shall be adjudged in three parts—one for our exchequer, another for public works, another for the judge of the case and the informer, each a half—after having deducted from the value of the wine the custom-house duties at the rate of 7 per cent as being earthy products; and besides we condemn the infringer of this law to $200 in assayed silver applied in the aforementioned way; * * * and the captain of the ship which brought it to Panama will be fined $2,000 in current money and exiled from the said city and from the Continental Kingdom for ten years, although he might contend that he brought it for his personal use and beverage; and the masters or owners of the barks and sloops which carried it from the port of Perico to the aforesaid city must pay, as a punishment, $200 in current money; and the citizen in possession of it shall lose it and be sentenced to $200, applied in the same way. We order besides that any minister of justice, citizen, inhabitant, or traveler in the said city can do the denunciations. * * * And it is our will that the same be understood also for the wine which should be landed in the islands of Perico, Taboga, and other places under any form; and that no grocer or any other person be bold enough to buy the said wine of Peru, to sell it at retail, under a fine of $100, in current money, with the same adjudication; and the grocer who should mix it with Castile wine in order to sell it again, or should have in his house a jug full of the said Peruvian wine, or empty, and it should be evident that in the said jug there was or had been carried some of that wine, let him be sentenced to $100 and be branded with public infamy.[1]

In the following years direct legislation was taken against regions farther north. It was ordered that the wine of Peru be neither sold nor bought in the Province of Guatemala.[2] But it was not enough to strike at the vine industry by trying to prevent the sale of indigenous products, by forbidding the disembarkation of the same, by forbidding the setting of new vines, by prohibiting the taxing of foreign wine merchants, and by ordering the destruction of old vineyards, which they feared they could not accomplish. Spain still tried to discourage the industry by prohibiting vine-growers from getting the needed manual labor for the planting, cultivation, and harvest of the crops from the Indians. In 1601 and in 1609 a law had been passed[3] prohibiting the apportionment of Indians for the cultivation of cocoa, the vine, and the olive. Another way to hinder vine-growing even upon shares was by prohibiting the daily wages of the Indians being paid in wine, etc., when working among the vines, this employment itself being illegal. It was ordered in the following language:

Let not the Indians who worked in the cultivation of the vines or in some other manual labor receive their daily pay in wine, molasses, honey, nor in Paraguay's grass,

[1] Don Philip III, this December 17, 1614, and March 2, 1619. Don Philip IV, in the Pardo, January 23, 1623, and in Madrid June 1, 1632.

[2] Don Philip III, May 18, 1615; Don Philip IV, June 19, 1626.

[3] Don Philip III, ordinances of 1601; May 26, 1609, chap. 24.

and whatever things of these kinds have been paid to them shall be forfeited and not be taken into account by the Indian.[1]

In considering the effects of these and other prohibitory measures adopted by Spain to enable her to control the trade of her colonies in the New World, we can not do better than to draw our views directly from the summary of the situation presented by Don Lucas Alaman. He says, in speaking of the prohibitions:

All had for object the hindrance to the cultivation and manufacture of those things which would have been prejudicial to the consumption of the agricultural and industrial products of Spain. Some of them reached their full effect, though through indirect means, as that relative to silk and tissues of the same, the cultivation and manufacture of which had considerably grown in New Spain, and became annihilated; that relative to vines, the progress of which was stopped.[2]

In the same connection Humboldt says:

When the obstacles which the Government has placed thus far on many branches of national industry shall be removed, when Mexican agriculture shall be no more enchained by a system of administration which impoverishes the colonies without enriching the Mother Country, the plantations of *maguey*[3] will be little by little replaced by vineyards. The culture of the vine will be especially extended with the number of the whites, who consume a great quantity of wines of Spain, of France, of Madeira, and the Canary Islands. But in the present state of things the vine can hardly be counted among the territorial riches of Mexico; so far the harvest from it has been inconsiderable.[4]

He further says that the best quality of grape is grown in the southern province of Oaxaca, but there are also vineyards near Dolores and San Luis de la Paz, to the north of Guanaxuato, and in the interior provinces, near Parras, in Coahuila, and Paso del Norte. The wine of the latter place was much esteemed.

It seems evident that the vine was cultivated throughout the entire extent of Mexico at the time of Humboldt's visit, and by the middle of the present century the vineyards were much extended. In 1854 the fruits at El Paso were "grapes, apples, pears, quinces, peaches, and apricots." Bartlett said in 1854:

The grape is the most extensively cultivated of all fruits. It resembles the Hamburg grape, though not quite so large, and is said to have been brought from Spain. There are both the white and purple varieties. Large vineyards of this delicious fruit are seen within the town and the district adjacent to El Paso. The vine is never staked or trailed. It is trimmed close in the fall, and in the spring it throws out its shoots from the very stump near which hangs the fruit. Each vine is kept separate, and the earth around free from weeds. Careful cultivators cover the vines during the winter with straw. With the first opening of spring the vineyards are irrigated, or rather inundated, for the water is suffered to flow over them and there remain until the ground is thoroughly saturated. This is generally all the water they get. In July the grapes come to maturity, and last fully three months. As may be supposed from the abundance of this fruit, it is exceeding cheap and forms a large por-

[1] Historia de Méjico, Don Lucas Alaman. Mexico, 1850, vol. III, pp. 29–32.

[2] The same in Aranjuez, May 26, 1609; in Madrid, October 10, 1618.

[3] *Agave Americana.*

[4] Essai Politique, Paris, 1811, vol. II, pp. 415, 416.

tion of the food of the inhabitants during the season. * * * Both the wine and the brandy are transported to various parts of New Mexico and Chihuahua, and some even finds its way to Durango.[1]

At the same period the vine was largely grown in the western provinces of Mexico, along the Californian Gulf. The same writer, in speaking of the Sonora Valley, says:

Of fruits there is a great abundance, including grapes, melons, figs, oranges, limes, lemons, citrons, peaches, and pomegranates. * * * But the vine is most extensively cultivated; not less than 1,500 barrels of brandy, 125 cuartillos each, are annually made. Of the quantity of wine made I have no knowledge, but that it is superior to that of the Rio Grande there is no question.[2]

Still farther down the coast of the Gulf of California, at Acapulco, the exports are silver, cochineal, cocoa, wine, oil, and Spanish wool.[3] Of Chihuahua it is said[4] that—

In the vicinity of the town are many fine gardens, which are irrigated from the aqueduct or the natural stream. * * * The fruits cultivated are apples, pears, peaches, figs, melons, and grapes.

At Parras, where it is known that vines have been grown for a great length of time, the vineyards were in a thrifty condition. Bartlett says:[5]

At the southern extremity of the town is a large estate belonging at present to Don ——— Arguire, called the "Hacienda Arriba," or the upper hacienda. * * * Its chief products are wine and wheat. The vineyards which surround it extend 1,200 varas (3,240 feet) into the plain, while beyond these are extensive fields of wheat and maize. It seldom rains here. The cultivation of the grape, as well as of the cereals, depends wholly upon irrigation. * * * About 10,000 gallons [of wine] are made here annually, for which there is a good market in Coahuila and the adjoining States. The wine vaults here were old in 1775.

Of San Lorenzo it is said that "vineyards and cornfields extend far and wide over the plain."

The facts now given are sufficient to show that the vine is cultivated throughout nearly all parts of Mexico. We seem justified in concluding that the vine (*Vitis vinifera*) was introduced into Mexico at the instance of Cortez, about 1525. All the evidence tends to show that it came from Spain as either seed or plant. Its spread in later years was slower in the northern than in the southern American colonies; but it gradually spread through Mexico, and, owing to the special needs of the Catholic Church for wine and the power of the Church to retain the vine and renew the stock and to introduce it into new regions against the will of the Mother Country, it at last became almost the special property of the Church. This condition of things was more or less

[1] Personal Narrative of Exploration, etc., by J. R. Bartlett, New York, 1854, vol. I, pp. 185, 186.

[2] *Ibid.*, p. 469.

[3] *Ibid.*, p. 503.

[4] *Ibid.*, vol. II, p. 437.

[5] *Ibid.*, pp. 486, 487.

marked through two centuries, beginning with the close of the sixteenth. As the missions had spread over the entire country, it is safe to say that the vine had so spread, as in fact we find it at the opening of the present century. During all this period of vine-growing no mention is found of the extensive death of vineyards. This is, of course, negative evidence, but the present state of the vine and its past existence, recorded from time to time, in spite of the efforts to extirpate it, form at least strong evidence of a healthful condition during this long period.

NOTES ON VINE-GROWING IN LOWER CALIFORNIA.

In 1533 the peninsula of Lower California was discovered by Jimenez, who supposed it to be an island. Cortez landed there in 1535 and established a colony, but no progress was made in colonization until 1697, over a century and a half later. In 1697 the mission of Loreto was founded. Goats, cattle, hogs, and sheep were brought at that time to Lower California.[1] By 1701 there was a garden of fruit trees and pot herbs at Loreto.[2] In 1702 wild vines are mentioned as being numerous in the river bottoms.[3]

At the end of the year 1700, Father Ugarte went from Loreto to the mission of Vigge Biaundo, and took charge of the work He found it a more fertile and extensive agricultural region than Loreto, and at once began to instruct the Indians in the art of tilling the soil, building, etc. Venegas says that Father Ugarte—

> Made a considerable quantity of generous wine, of which, after supplying the missions in California, some was sent to New Spain in exchange for other commodities. * * * In the year 1707 all New Spain suffered extremely for want of rain; Cinaloa and Sonora were likewise reduced to great distress. California also had been without rain, yet Father Ugarte, writing to Don Joseph de Mirande, on the 9th of June, tells him: "It is now two months since seamen and landsmen began to eat here good bread of our own harvests, while the poor on the other coast in Cinaloa and Sonora, are perishing.[4]

In another place Venegas, in speaking of the customs in practice at the missions, says:

> Wine is the only product withheld from them [the Indians], and this in order to prevent drunkenness; and it is for this reason that, although the vintages are but inconsiderable, some quantities of it, there being but few consumers in California, have been exported to New Spain in exchange for other commodities. What wine the father has is chiefly given to the sick, whom he likewise supplies with medicines.[5]

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[1] California, by Father Miguel Venegas, Madrid, 1758; English edition, London, 1759, vol. I, p. 232.

[2] *Ibid.*, p. 316.

[3] From a letter by Father François Marie Piccolo, written in 1702, and quoted by William Ingham Kip in "Historical Scenes from the Old Jesuit Missions," p. 58, *et seq.*

[4] California, Venegas, vol. I, pp. 320–321.

[5] *Ibid.*, pp. 433–434. Also mentioned by Forbes in his California. London, 1839, p. 51.

After speaking of the indigenous plants of Lower California, Father Venegas mentions those imported to that region, giving their source. This is of interest as bridging over the source of the vine from New Spain. He says:

Besides these trees and roots, here are others which have been transplanted by the missionaries from the continent, and most of them with very good success, especially in those parts where they have the conveniency of water; so that the banks of the rivers, canals, and watering places are decorated with olives, fig trees, and vines; and in some parts, the latter have throve so well as to afford a wine equal to the best in Europe.

Venegas further says that Father Ugarte "brought hither almost every kind of fruit tree growing in New Spain; and having planted them in a properly prepared soil on the coast of San Miguel, and kept them daily watered, they all flourished."[1] After the establishment of the mission of San Ignacio, in 1728, Father Luyando planted there vines, olive, and fig trees, etc.[2]

Loreto never grew to be of any considerable size, but the vine was grown there on a small scale at an early date, and has been preserved. It was probably the place where vines were first introduced into California, whether they were included among the plants in the garden there in 1701 or not. It is also of interest as being the starting point for the numerous missions subsequently founded in a chain all along the Pacific coast, which have ever pushed forward viticulture into new regions. Hittell, obtaining his information from Father Baegert, who writes of 1768, says: "Five of the missions had vineyards; and the grapes were sweet and delicious." "There was enough [wine] to supply all the missions of the peninsula and a number of those on the other side of the gulf."[3]

Hardy, writing of Loreto in 1829, says:[4]

There are two gardens in the place, in which the vine, peach, fig, quince, and date are cultivated. A considerable quantity of wine is annually made. * * * The exportations consist of soap, preserved fruit, wines, spirits, pearls, tortoise shell, and salt.

It is thus seen that before 1700 the two missions of Loreto and Vigge Biaundo had been founded in Lower California. During the first half of the eighteenth century a long line of missions was established along nearly the entire length of the peninsula. It was from these that much of the material was taken to supply the needs of the new missions in Upper California; and that five of these missions had been supplied with vineyards previous to 1769 has already been shown.

The vines in these old missions of Lower California are still alive. Alexander Forbes, in writing in 1835, says that besides—

Indian corn, the sheltered valleys near the different missions produce a variety of fruit, such as grapes, dates, figs, quinces, peaches, pears, olives. The dates, figs, etc.,

[1] California Venegas, vol. I, p. 45.
[2] California, Forbes, p. 51.
[3] Baegert, Pt. III, § 5, pp. 441–445.
[4] Travels in Mexico. London, 1829, p. 244.

are dried and preserved and exported, and wine is made from the grapes and also exported.[1]

Rodman M. Price, in writing of Lower California as seen in 1846 and 1847, says that in the valley of San Jose, 20 miles north of Cape St. Lucas, oranges, lemons, bananas, plantains, figs, dates, grapes, pomegranates, and olives were cultivated, while raisins and other dried fruits were exported.[2] As a matter of fact, the vine has now been grown in Lower California, with greater or less success, for upward of one hundred and eighty years. It is the Mission grape, the same variety so largely grown in California at present. I have examined many old vines of this variety at Ensenada.

That the Mission vine came from Mexico proper to Loreto is sustained by the records already presented, and it is also indicated by the fact that the same vine is found as far north as the northern boundary of eastern Mexico and beyond. It has evidently pushed across the country both to the northward and westward. At the north it was introduced into Texas, New Mexico, etc., while the western branch crossed into Lower California and was diverted northward along the Pacific coast into California proper. In support of the idea that this vine was first imported from Spain, we may give the views of Hyatt. This gentleman spent some time in Morocco, where he owned a vineyard. In his handbook on vine culture in California,[3] he says that the Mission grape of California very much resembles a grape he has seen in Morocco, which had been taken to that country, he presumes, from Spain by the Moors after the conquest. It would be of interest to learn whether the Mission grape exists in Morocco and if the original stock came from Spain. There is at least a chance of demonstrating in this way the source of our grape, and of ascertaining whether the importation was direct or indirect. The species of *Vitis* to which the Mission grape belongs is sufficient at least to establish its transatlantic origin.

The following letters are of interest as giving some present theories as to the introduction of this variety. They also show that Mission vines have been successfully raised through Lower California, and have so far been exempt from disease.

UNITED STATES CONSULATE,
Ensenada, Mexico, January 26, 1891.

DEAR SIR: In reply to your letter of the 14th instant, inquiring as to certain facts about the Mission grape, I beg to say that the result of the investigation I have made may be summed up in the following: The Mission grape is grown hereabouts, but it is difficult to say when it was first introduced. The old mission fathers who first brought it here from northern Spain [?] left no records as to this. It was planted by these fathers in nearly all the old missions in Lower California, I am informed. In most of these missions the vine is still growing. It is growing success-

[1] California. London, 1839, p. 63.

[2] Quoted in "What I Saw in California," by Edwin Bryant, 1848, pp. 408–409.

[3] Handbook of Grape Culture, revised edition, San Francisco, 1876, p. 163.

fully at the Mission St. Tomas—about 30 miles from here, where it was introduced fully one hundred and thirty years ago. It is said by the old Mexican residents to be remarkably free from diseases of all kinds.

Yours truly,

ANTHONY GODBE,
U. S. Vice-Consul.

UNITED STATES CONSULATE,
La Paz, Mexico, February 18, 1891.

DEAR SIR: Your letter of the 14th ultimo, relative to the Mission grape vine, is hereby respectfully acknowledged.

In answer to the questions contained therein, I would state that the missionaries who emigrated to this peninsula from Spain, in 1642, introduced this species of vine from said country. It is now cultivated throughout most all the old missions established by them and also in many other places, with perfect success. It is all of the same variety, but in some missions it seems to be produced more successfully than at others, as, for instance, at a place called Patrocinio, near the old mission of San Ignacio; the wine made from the grape produced at said place is very similar to superior Madeira wine, while the wine made at the Purisima mission is a wine that if left for two years it is quite equal to Spanish sherry, it being an excellent dry wine.

The vines in this Territory are considered to produce the finest grapes of any part of the Republic. No disease has ever attacked them as yet, with the exception of a few white bugs which you frequently find on the vines, but not enough to impair their growth.

The exact or approximate date as to when it was first brought to this country is difficult to ascertain.

I remain, respectfully,

JAS. VIOSCA,
U. S. Consul.

INTRODUCTION AND SPREAD OF THE MISSION VINE IN UPPER CALIFORNIA.

Upper California remained unoccupied, except by the Indians, until 1769, although several brief visits to its shores by various navigators gave to the world prior to that date many facts relative to its physical features and natural resources. Bancroft says:

> Cabrillo entered Upper Californian waters, never before disturbed by other craft than the Indian canoes, and anchored in San Diego Bay in September, 1542. If we suppose this port to have been his San Miguel, he remained six days. * * * Sebastian Vicaino, commanding a Spanish exploring fleet of three vessels, anchored in San Diego Bay on November 10, 1603. * * * After a stay of ten days they set sail on the 20th of November."[1]

After the brief visit of Sebastian Vizcaino, in 1603, the region about San Diego remained unexplored for more than one hundred and sixty years, or until about 1768, when material was brought together in Mexico and Lower California to found a mission on its shores. Expeditions were undertaken by land and by sea, most of the property going by water. The land expedition visited each of the missions of Lower

[1] History of California, by H. H. Bancroft. San Francisco, vol. I, pp. 69–70, 97–99.

California on its journey northward. Father Rivera, in charge of this division, took from each mission "such live stock and other needed supplies as he and the different friars thought could be spared."[1] Palou gives a list of some of the articles sent, and among other things are bottles and jugs of wine, thus establishing the existence of vineyards at some of the points whence goods were consigned. The president of the missions, Father Junipero Serra, had been located at Loreto in the early part of the winter of 1769, where he had been busily "engaged in preparations, forwarding such articles as he could get to La Paz or to Santa Maria, according as they were to go by water or by land."[2]

The first vessel to arrive at San Diego was the *San Antonio*, on April 11, 1769. The second vessel was the *San Cárlos*, on April 29 of the same year. The cargo contained, among other things, "6 jars of Cal. wine" and "5 jars of brandy."[3] We have here another record of wine-making in Lower California, at the points furnishing the supplies. It is stated in Palou's Life of Junipero Serra (p. 25), that the ships were provided with "all kinds of orchard and other seeds." Other consignments of supplies reached the new missions by water within the two following years.

The first part of the land expedition reached San Diego May 14, 1769, while the body of the second division arrived on July 1. The mission was formally founded on July 16, 1769. The lists of articles brought to this mission are by no means complete, and it is not strange that vine cuttings, if present in the supplies, are not enumerated. Bancroft says[4] that "many varieties of fruit, including probably grapes, were introduced from the peninsula by the earliest expeditions between 1769 and 1773." In evidence of this he says: "Vallejo has heard from his father and others of the *fundadores* that vines were brought up in 1769, and planted at San Diego."[5]

Mr. A. Haraszthy, in writing in 1858 of the early history of vine culture in California,[6] says the vine "was brought to California by the Catholic priests in the year 1740 or thereabouts, and was planted at the Mission San Diego and Mission Viecho, situated about 60 miles from San Diego, in Lower California." No references are given by Mr. Haraszthy, and this view of the matter may have been gathered from hearsay, for he continues:

> Tradition says that said grape vines and olive trees were brought at one and the same time from Spain.

There are other facts which lead us to believe the vine was brought to San Diego from Lower California, chief among which is the uniformity of variety of the vine in the two regions. There was, in fact, an entire

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[1] Bancroft, *ibid.*, p. 121.

[2] *Ibid.*, vol. I, p. 121.

[3] *Ibid.*, vol. I, pp. 128–129.

[4] *Ibid.*, p. 619.

[5] *Ibid.*, note to p. 619.

[6] Early history of vine culture in California. Trans. California State Agric. Soc., 1858.

absence of any other variety in early days, so far as we have learned, in both districts. On this subject Mr. Haraszthy writes:[1]

> Our modern California grapes were, to all appearances, multiplied from these vines [the Mission vines], set out originally in the above-named places [San Diego and mission Viecho]. It is certain that no other quality than this can be discovered among the native vines at the present age, and it is almost impossible that if several varieties had been imported at that period, they would have so completely run out as to leave no marks of distinction whatever.

It seems to me that the conclusion can not be avoided that the Mission vine of Upper California was brought from the missions of Lower California, where only this variety was known to have existed. The missions had full possession of the first vineyards in Upper California. They were founded by expeditions from the missions of Lower California; and wine had been made at these missions for over sixty years, and was supplied by them directly to the new missions. Five of these missions are known to have had vineyards when contributions were drawn from them for the northern missions. The Church was the only power having the confidence to stand up against the Mother Country, Spain, in the planting, cultivation, and harvesting of the crop, and spreading of the vine in new regions; and we find this church, as a matter of fact, in full possession of this production in both Californias. Any doubts remaining as to the immediate source of this vine should be dispelled by the following clear statement of Francisco Palou. Palou was writing of the life and times of Padre Junipero Serra. Junipero Serra died in 1784, hence the facts given about California relate to the period between the founding of mission San Diego, in 1769, and the death of the venerable father in 1784, a period of some fifteen years. Palou was personally familiar with the situation in California at that time. He says:[2]

> Having observed from the very beginning [of the mission] that all this earth was adorned with wild vines that had the aspect of vineyards, they began to set cultivated shoots brought from old California, and they already obtain wine, not only for masses, but also for drinking, together with fruits of Castile, such as pomegranates, peaches, apricots, quinces, etc., and also very good pot herbs.

The following outline, showing the order of the founding of different missions in California, will indicate how and when the vine was probably introduced at various places.

In southern California the first mission to be founded after that at San Diego, in 1769, was the mission San Gabriel, in 1771. It was here that the vineyards became best developed, and San Gabriel became the central point for the distribution of vines to several of the more northern missions in southern California.

Capistrano mission was probably supplied from San Diego, as from there the materials came for its establishment in 1776, and it was soon

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[1] Early history of vine culture in California. Trans. California State Agric. Soc., 1858.

[2] *Vida del V. Padre F. Junipero Serra. Por el R. P. L. Fr. Francisco Palou:* Mexico, 1787, p. 199.

producing wine. Los Angeles was established in 1781, and founded from the San Gabriel mission. Its mission vines are reported[1] to have been brought from San Gabriel in 1786 or 1787.

San Buenaventura was founded from San Gabriel March 30, 1782. It is probable that the vine was introduced here about the time of the settlement of the place. Eleven years after, in 1793, Vancouver stopped at this port, and he visited and described the garden there.[2]

He also says further on in his writings:

> The garden of Buenaventura far exceeded anything of that description I have before met with in these regions, both in respect of the quality and quantity, and in the variety of its excellent productions, not only indigenous to the country, but appertaining to the temperate as well as the torrid zone; not one species having yet been sown, or planted, that had not flourished and yielded its fruit in abundance and of excellent quality. These have principally consisted of apples, pears, plums, figs, oranges, grapes, peaches, and pomegranates, * * * and a great variety of the necessary and useful kitchen herbs, plants, and roots. All these are flourishing in the greatest health and perfection, though separated from the seaside only by two or three fields of corn that were cultivated within a few yards of the surf.[3]

Santa Barbara Presidio was established April 21, 1782; but its mission was not founded until 1786. The latter was supplied from San Buenaventura, and grapes were soon grown. The gardens and vineyards were enclosed by a wall, in 1799, which was 1,200 yards in length.[4] The archives of the Santa Barbara mission contain records of wine-making in the southern missions in 1797–1798.[5]

Near Santa Barbara, at Montecito, the old mission vine of great size, noted in nearly all works on California, was planted as far back as 1795. This vine lived till about 1875, when it was placed on exhibition at the Centennial Exposition at Philadelphia. Its diameter was 15 to 18 inches, and it bore crops of tons of grapes. One year over 5 tons were produced. Its great age and thrifty growth are of interest here.

San Fernando mission was established September 8, 1797; and was supplied from Santa Barbara. It became one of the richest of missions in later days, and grew grapes of the Mission variety successfully for many years. In 1835 there were "32,000 vines, worth $16,000."[6] In 1838 an inventory gives the value of liquors, etc., at $7,175. In 1840 the brandy and wine amounted to "58 barrels, worth $2,360."

The mission of San Luis Rey was established on June 13, 1798, from San Diego. It had grapes early in its history and retained them for many years. As late as 1858 old vines were reported 1 mile west of this mission. One vineyard had 1,000 old vines, and there was another toward the northwest.[7]

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[1] Letter from A. F. Coronel, dated Los Angeles, Oct. 17, 1889.

[2] Voyage of Discovery, London, 1798, pp. 55, 458.

[3] *Ibid.*, p. 494.

[4] History of California, Bancroft, vol. I, p. 673.

[5] *Ibid.*, p. 619.

[6] *Ibid.*, vol. II, p. 647.

[7] Report of a committee of the California Agricultural Society.

The San Bernardino mission was founded in 1820 by a colony from the San Gabriel mission, but the extent of vine-growing at this point was not ascertained. It is certain, however, that vines have been grown here for many years with decided success.

This constitutes an outline of the introduction of the vine into southern California and its spread in this part of the State. In the northern missions its history is much the same. The Mission vine was found at nearly all of the missions shortly after their founding, but vines were sent to the missions north of San Francisco from another source at a somewhat later date.

Of records relating to the more northern portions of the State there is one of the planting of trees and vines at Ross. Some of these vines were brought from Lima in 1817, and bore fruit in 1823.[1] Other vines and vineyards are mentioned at the same place somewhat later. Hittell says that when the missions were established north of the Bay of San Francisco, a new variety, now called the Sonoma grape, and said by Gen. Vallejo to be of Madeira stock, was introduced. He says the Sonoma grape makes a light wine resembling claret, while the Los Angeles [Mission] grape makes a strong wine, resembling port or sherry. He also says these were the only varieties cultivated there previous to 1853. The later development of the grape industry is outlined below.

VINE INDUSTRY OF SOUTHERN CALIFORNIA PRIOR TO 1884.

Anything approaching a complete history of vine culture in California is not to be expected here. The facts given are intended to outline the history of the industry in southern California prior to the appearance of the disease, or to the general death of the vines.

Shortly after the opening of the present century, about 1803, Humboldt visited Mexico and spent a year in the study of that and adjoining regions. He says, in referring to the situation in California:

> In the eighteen missions which now exist in New California, wheat, maize, and haricots (*frisoles*) are cultivated in abundance. Barley, beans, lentils, and *garbanzos* grow very well in the fields in the greatest part of the province. As the thirty-six monks of St. Francis who govern these missions are all Europeans, they have carefully introduced into the gardens of the Indians the greater part of the roots and fruit trees cultivated in Spain. The first colonists found, on arrival there in 1769, shoots of wild vines in the interior of the country, which yielded very large grapes of a very sour quality. It was perhaps one of the numerous species of *Vitis* peculiar to Canada, Louisiana, and New Biscany, which are still very imperfectly known to botanists. The missionaries introduced into California the vine (*Vitis vinifera*), of which the Greeks and Romans diffused the cultivation throughout Europe, and which is certainly a stranger to the New Continent. Good wine is made in the villages of San Diego, San Juan Capistrano, San Gabriel, San Buenaventura, Santa Barbara, San Luis Obispo, Santa Clara, and San José, and all along the coast, south and north of Monterey, to beyond the 37° of latitude.[2]

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[1] Bancroft, vol. II, p. 637.

[2] Political essay on the kingdom of New Spain. London, 1822, vol. II, p. 294. (Book III of the original, Chap. VIII.)

The mission property continued to increase from year to year until 1814, when the missions were in their prime. After that date, Hittell tells us[1] they were injured by the stoppage of pay and other consequences of the Mexican revolution, although they continued to increase in population and property until 1826.

In 1822 Capt. John Hall, in his log book of a voyage to the coasts of California, states that at Santa Barbara all kinds of fruits, including grapes, pears, etc., were cheap. At San Juan good wine, either white or red, could be procured from the friars. Grapes were found in great abundance at San Diego, and good wine was made from them.[2]

Guerra, in 1827, noted that at Santa Barbara the making of wine and brandy might be made profitable if foreign liquors could be excluded or heavily taxed. The commercial side of the question was then attracting attention.[3] Bancroft says that Duhaut Cilly visited Los Angeles in 1827 and found the chief crops to be corn and grapes. Vines flourished very well, but the wine and brandy were very inferior to the exquisite flavor of the grape. He was of the opinion that this inferiority was due rather to the manner of making the wine than to the quality of the soil.[4]

In 1828, wines and liquors were made at San Juan Capistrano. The wines were strong, and, Pattie says, the padre often overindulged.[5] At this time the Santa Ana, San Joaquin, Trabuco, and San Mateo ranches, together with the dry and torrent rivers, according to season, are mentioned.

In 1830, the Santa Margarita ranch is spoken of as having a house, garden, vineyard, and land fit for all crops.[5] Mission vines have apparently been grown on this ranch for many years, and are still grown there of considerable size, as I observed in 1889. If, as seems probable, they have grown there without intermission, they have had a life of over sixty years. At all events, the vines there now are old. In 1834, there were four vineyards at San Gabriel, which contained 165,579 vines.[6]

Alexander Forbes, in 1835, says that an indigenous variety of vine, yielding grapes of a considerable size but not ripening to sweetness, was found by the early settlers; and that the fathers introduced the true wine grape (*Vitis vinifera*), which had long flourished in Lower California. In many parts of California the native vine was so plentiful and its produce so abundant that brandy was made from it in considerable quantity. He says the country embraces the analogues, at least, of the most celebrated wine countries in the world, and that consequently it offers a wide and most promising field for the cultivation of the grape in all its varieties.[7] He says also that the vine thrives remarkably in

[1] Resources of California, San Francisco, 1874, pp. 79–80.
[2] Appendix to Forbes's California. London, 1839.
[3] History of California, by H. H. Bancroft, vol. II, p. 574.
[4] *Ibid.*, pp. 563–564.
[5] *Ibid.*, p. 556.
[6] Bancroft, vol. III, p. 643.
[7] California, p. 173.

California, and that it was cultivated to a considerable degree, which might be extended almost without limits. Wine was then made of tolerably good quality, some of it being excellent. Nothing was wanting but intelligent persons to make it of a superior quality, and it would find a ready market in Mexico and in the neighboring countries where the vine does not grow.

The quantity of wine and brandy consumed in those countries is immense, all of which could be supplied from California at a price infinitely less than what is now paid for that brought from Europe. Raisins also, the produce of the vine, are articles of considerable consumption, so that this branch of industry would be a source of great riches to an enterprising and industrious people; but at present, instead of exporting either wine or brandy, they have to purchase them for their own use.[1]

Forbes also states that the region about Los Angeles was "occupied by vineyards and maize fields" in 1835. San Fernando had in this year 32,000 vines worth $16,000. Hartnell said, in 1839, there were 8,600 vines in two vineyards at San Diego. At Santa Isabel there were 5,860 vines, while Santa Monica had 8,000 vines.[2] At San Buenaventura an inventory made in July gave 5 barrels of brandy and 13 barrels of wine.

About 1841, Farnham says, at the mission of Santa Barbara were cultivated large tracts of land to grapes and other crops, and that the old vineyards still covered the hillsides.[3] Writing in 1879, J. de Barth Shorb says that the first important vineyards were planted at San Gabriel, and that the old vines were still in a flourishing condition in 1841.[4] Hittell quotes Mr. A. Robinson as saying, in 1846, that the vineyards at San Gabriel were so productive that the missionaries made annually from 400 to 600 barrels of wine, and 200 of brandy, from which they derived an annual income of over $1,200.[5] Robinson's observations were made in California prior to 1842.

In 1845 Robert Greenhow stated that—

At a distance of 30 miles north of San Pedro stands Pueblo de los Angeles, the largest town in California, containing a thousand inhabitants; and near it is the mission of San Gabriel, the vineyard of which formerly yielded a large supply of good wine.

At Santa Barbara, in 1845, there was of mission property 512 fruit trees and two vineyards of 1,295 and 2,400 vines, respectively. Bryant, writing in 1846, says[6] that at the Pueblo de San José the grapevines were bowed to the ground with fruit. At San Luis Obispo he noticed the orange, fig, palm, olive, and grape. At San Fernando there were oranges, lemons, figs, olives, and extensive vineyards. Respecting Los Angeles he says that the San Gabriel River was skirted with numerous

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[1] California, p. 264.

[2] Bancroft, *ibid.*, vol. III, pp. 619 and 660.

[3] Early days in California. Philadelphia, 1862, p. 110.

[4] Rept. State Agric. Soc., 1879.

[5] Hittell, History of California, vol. II, p. 474.

[6] What I saw in California. 1848, pp. 316, 375, 376, 391, 405, 406, 412.

vineyards and gardens. The yield of the vineyards was very abundant, and a large quantity of both wine and *aguardiénte* were manufactured there. He understood some of the vineyards contained 20,000 vines. He believed the produce of the vine in California would undoubtedly in a short time form an important item in its exports and commerce. The soil and climate, especially in the southern portion of the country, he considers particularly adapted to the culture of the grape. Mr. Wolfskill's vineyard was young, Bryant states, and covered about 40 acres, the number of vines being 4,000 or 5,000. [These figures were undoubtedly intended to be 40,000 or 50,000, which would be about right for 40 acres of vines set in those times, when the custom was to plant them much closer than at present.] From the produce of this vineyard Mr. Wolfskill had made 180 casks of wine the preceding year, and the same quantity of *aguardiénte*. The quantity of wine and *aguardiénte* produced at that time in California Bryant supposes to have amounted to 1,600,000 gallons.

Larkin says considerable quantities of wine and brandy were exported from California in 1846.[1] John S. Hittell says that there were probably 200,000 bearing vines in California in 1848; and in 1874 he says, "they still continue productive."[2] That vines were as productive in 1851 as at present is shown by the writings of John J. Werth,[3] who mentions grapes from southern California vineyards in bunches of 2 to 4 pounds, and adds that they were credibly reported to reach 8 pounds. I have myself had a bunch picked from the vines weighing over 4½ pounds and measuring 17½ inches in length and 9½ inches in breadth.

In speaking of the vicinity of Los Angeles about 1852 J. R. Bartlett says that there were many large haciendas and ranchos in the valley, which was in a high state of cultivation, abounding in orchards and vineyards. Respecting the San Gabriel mission he quotes from the Los Angeles Star to the effect that authentic records are known to exist showing that at one time the mission manufactured 3,000 barrels of wine and harvested 262,000 bushels of grain in a year. Of the San Diego mission he says it was the last to be abandoned; that formerly there was a large vineyard and orchard there, parts of which still remained.[4]

According to Hittell the first direct importation of foreign vines occurred in 1853, and was made by nurserymen.[5] These grapes came to the northern part of the State. In 1854 still other vines were imported, but there was little demand for them. The Mission vine was grown in large numbers nearly everywhere through the State. Native cuttings

[1] Bancroft. *Ibid.*, vol. v, p. 570.

[2] Resources of California, 1874, p. 244, etc.

[3] Dissertation on the resources and policy of California, Benicia, 1851, p. 70.

[4] Personal Narrative of Exploration, New York, 1854, vol. 2, pp. 82, 83, 103, 104. Resources of California, pp. 244, 245. According to Gustav Eisen (The Raisin Industry of California, p. 38) Col. A. Haraszthy imported the Muscat of Alexandria, from Malaga in March, 1852. At present I know of no earlier date.

could be had more cheaply and in greater numbers than the foreign ones, and it was not strange that the Mission vine held its own. About this time the agricultural interests of the State were awakening, for it was in this year that the State Agricultural Society was authorized, the bill passing the assembly and senate, and receiving the signature of the governor May 13, 1854. The interest in foreign vines now began to gain some ground, and in 1855 still more of them were imported. The number of grapevines in the State in 1855 is said to have been 324,234, an increase since 1848 of 124,000.

In 1856 the business of growing grapes and making wine for the market began in earnest.[1] The new vineyards set in that year were largely of the Mission variety. It is estimated that the number of vines in the State that year was 1,442,491, a very great increase over the previous year's estimate. In 1858 Mr. A. Haraszthy gives estimates of the number of vines in the southern part of the State in 1846, and his figures show that considerably more than half the vines in the State were then in the four southern counties. Los Angeles County had a majority of all the vines in the State. The figures are as follows: Los Angeles County, 726,000 vines; San Bernardino County, 80,000 vines; San Diego County, 4,000 vines; Santa Barbara County, 15,000 vines; making a total of 825,000 vines. The figures should only be taken as approximate, as there was no accurate count made. There are recorded a less number of vines for 1857 than for 1856, the discrepancy being probably due to incorrect returns.[2]

In 1857 it is said there were 2,048,241 vines in the State. The record for the southern part of the State was as follows: Los Angeles County, 600,000 vines; San Bernardino County, 38,000; San Diego County, 4,000; Santa Barbara County, 70,000. Although for some reason unknown to me the record in the southern counties is reduced this year, it is very greatly increased the following year. In 1857 the site of Anaheim was purchased and plans were laid for the future vineyards, where the disease considered in this Bulletin first began its destructive work. Mr. John S. Hittell, who was a former stockholder at Anaheim, says:

> Anaheim is the only German town in the State. It was laid out by Germans, built up by Germans, and is in the main populated and owned by Germans. But it will never have the foreign character which marks many German villages in the valley States of the Mississippi, where the English language is not known to any of the people. None of the Anaheimers have come direct from Germany; all of them have lived for some time elsewhere in the United States, and most of them speak English fluently. The English language will be the predominant tongue, although German will long be cherished. Anaheim is a tract of land a mile wide by a mile and a half long, in the valley of the Santa Ana River, Los Angeles County [now Orange County]. It was unoccupied and supposed to be of little value in 1857, when it was bought for $2 an acre by a German company of fifty members, mostly residents in San Francisco.

[1] Hittell. Resources of California, pp. 244, 245. According to Gustav Eisen (The Raisin Industry of California, p. 38) Col. A. Haraszthy imported the Muscat of Alexandria, from Malaga, in March, 1852. At present I know of no earlier date.

[2] Early history of vine-culture in California. Trans. Cal. State Agric. Soc., 1858.

They were incorporated as a joint stock association. The land, containing 1,168 acres, was divided into fifty lots of 20 acres each, with a little town plat in the middle, and convenient streets. The place was given in charge of a superintendent, who held his position two years, in which time he planted and cultivated 8 acres of every lot with vines, and put willow hedges (nearly all the fences in Los Angeles County are willow) around the outer boundary of the tract, and along the principal streets inside. During a large part of the time he hired fifty laborers. The total expense for the two years was $70,000, or $1,400 per lot of 20 acres, including 8 acres of vines. The owner of a vineyard lot had a little town lot of half an acre besides. In December of 1859 the property was divided by lot among the members, many of whom afterward moved to the place and made their homes.

In 1858 the vines of California numbered 4,090,026; in southern California they were distributed as follows: Los Angeles County, 1,650,000 vines; San Bernardino, 75,000; San Diego, 50,000; Santa Barbara, 90,000. Mr. A. Haraszthy, writing in 1858,[1] said that the California climate, with the exception of the seacoast, especially where the prevailing western winds drive the fogs over the locality, is eminently adapted for the culture of grapevines, and it is proved conclusively that no European locality can equal, within 200 per cent, its productiveness. He further said that the oldest inhabitants have no recollection of a failure in the crop of grapes. Vineyards planted in various counties, beginning at San Diego and extending to Shasta, have given magnificent returns. The same prominent viticulturist compares the Californian with foreign vines. He considers that the age of the vine depends on its pruning, the distance of the vines from each other, and the climate. In France a vineyard planted 2½ to 3 feet apart and 2 feet in the rows and trimmed spur fashion will be very feeble when twenty years old, and almost worthless. In Italy, in Greece, Smyrna, etc., where close planting is not the custom, the vines reach an age of from one hundred to two hundred years or more, and will bear every year a crop of from 1,000 to 2,000, even up to 4,000, bunches of the largest size. He states that California seems to possess even greater power of keeping the vines in vigor many years, notwithstanding injudicious trimming. There are missions in southern California where vines are eighty years old, and with good care will last treble and quadruple that length of time. He believes a vineyard planted 8 feet apart each way and pruned on the alternative system will last three hundred years and be vigorous. These are the views of one of the leading and best informed viticulturists in California in 1858, and these opinions as to the life of vines are largely founded on the situation as it then existed in the southern part of the State. The reader should not fail to compare these views with the present situation as given in this Bulletin under the head of "The Growth of Cuttings."

It was in the same year, 1858, that the California State Agricultural Society was incorporated, and a committee was appointed to visit the various fruit regions of the State and report. From this report we are able to gather facts relative to the condition of several of the old mis-

[1] Early history of vine-culture in California. Trans. Cal. State Agric. Soc., 1858.

sion vineyards thirty-three years ago. The committee says that the improvements about the San Diego mission, originally very extensive, were in a state of decay. The vineyard was entirely destroyed, and of the orchards scarcely a tree, besides the olives and a few date palms, remained alive. At San Isabel the old building was in a tolerable condition, and the two vineyards were well cultivated and doing finely. On the place of Col. Couts, at Guajomita, vines were found four years old and doing well. One mile below the mission of San Luis Rey they found another orchard and vineyard of 1,000 old vines, and another in a northwesterly direction at nearly an equal distance. All were cultivated and enjoyed by the Indians, many of whom exhibited considerable industry and enterprise. At San Juan Capistrano no mention of vineyards is made, but fruit trees are mentioned, such as the pear, peach, fig, and olive, which, though appearing old, were full of fruit. On June 24, 1858, the committee arrived at the Santa Ana ranch. This old establishment was in ruins. The next point visited was the site of the present town of Anaheim. As the description was of matters as observed on the ground I give it in full, believing that too many facts relating to the early history of this place can not be given in this connection. The report says:

During the afternoon we passed the large establishment of the Los Angeles Vineyard Society, situated 26 miles southeast of the city of Los Angeles. This society is composed mostly of Germans, fifty in number, and was originally designed, by a combination of small amounts, to furnish good homes and fair returns for the proprietors. The company was duly organized, a suitable and desirable location sought, and 1,200 acres of land purchased. * * * After one year the place is fenced, and one-half well cultivated and planted with 500,000 vines, which are in prosperous condition; a water main 10 miles long, bringing from the mountains ample means for irrigation; and 400 miles of *zanka*, or small ditch, for conducting the water through the place; the ground prepared for 500,000 more vines; and $7,000 funds still in the treasury. Should corresponding success continue, and the original design not be frustrated by the purchase and consolidation of shares, these fifty families will, in a few years, each own a good house, with an orchard of sufficient extent for domestic use and a vineyard of 20,000 vines.

The vines set out in this extensive vineyard tract were mostly of the Mission variety. At Los Angeles the vineyard of Dr. T. J. White is said by the visitors to have contained 16,000 vines, two-thirds of which were 8 years old, and one-third 15 years old, all in full bearing; and he was then about to plant 20,000 more. The vineyard of Dr. Hoover, adjoining that of Dr. White, consisting of 7,000 vines, was well cultivated and in full bearing. The report says:

Some of the vines over 80 years old are more heavily laden with fruit than any that are younger.

This is a valuable record and one taken upon the spot. Another of like character and importance is that relative to the vines of Sainsevaine Brothers. It is said:

They have 41 acres in vineyard, from which they made last year 60,000 gallons of wine. The age of their vines ranges from 10 to 60 years, the oldest being the most productive.

The vineyard of another gentleman contained 7,000 vines, all thoroughly cultivated and doing well. The vineyard of Mr. William Wolfskill was said to contain 60,000 vines, the youngest of which were 12 years old, from which a large amount of wine was made. Capt. John Roland's place is said to contain 17,000 vines in a most prosperous condition. The place of Messrs. Froehling and Kohler contained 15,800 vines from 12 to 14 years old, from which they made some 30,000 gallons of wine. Besides these vineyards the committee mention that of Mr. Childs, with some 8,000 vines; and that of Mathew Keller, which is said to have contained "8,300 vines of twelve sorts of all ages from 1 to 54 years." East of Los Angeles the vineyard of Mr. W. W. Rubottom was visited. It consisted of 15,000 vines, young, but promising well. The vineyard of William Workman is said to have contained 10,000 vines in fine bearing. Still further east the vineyard of Capt. John Roland contained 15,000 vines 13 years old, and bearing very heavily. Five thousand five hundred vines on the place of John Rubideau were doing well, as also his general assortment of fruit trees. They sometimes have frost enough, it is said, to kill the more tender varieties of trees. Speaking of the "Coco-mungo Rancho" the committee remarked that it was eminently adapted to produce the best classes of long-keeping wine. It is also said:

> There is no question but this section of country must become immensely rich, at no distant day. Its wine-growing capacities surpass the most extravagant anticipations of those who have not seen it.

The vineyard of the old mission San Gabriel, 78 years old, "and containing many thousand vines, is in a state of ruin." This condition is explained as follows:

> Several years since a man squatted on the property containing the vineyard, and has, up to the present time, succeeded in retaining possession, but has left the fence to go to decay; and for years it has been exposed to the ravages of stock which have fed upon its tender branches as fast as they have appeared. Yet, strange though it be, these vines, in a dry gravelly soil, without irrigation and continually browsed by cattle, live, and occasionally we saw one hiding a small cluster of grapes near the ground, or among the lower branches.

We see from this that these vines, though 78 years old, and treated in the most severe manner, were still living; and it has already been stated that vines 80 years old at Los Angeles, which had been properly cared for, were thrifty and bearing well. As the old San Gabriel vineyard was no great distance from Los Angeles, we can say that both vineyards would probably have been in much the same condition under the same treatment. There were reported to be 16,000 bearing and 22,000 young vines on the place of Hon. B. D. Wilson. Capt. Dorsey had a young vineyard of 22,000 vines. He also had 1,000 vines of a new variety of grapes, discovered by him in a mountain gorge a few miles distant. The wood resembles that of the Catawba, but the fruit is described as entirely different.[1]

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[1] From the Rept. of the Cal. State Board of Agric. for 1858.

This report of the situation in southern California in 1858 is invaluable. It gives the true condition of affairs over the region now suffering from disease, and shows that the vines in all parts of the region were healthy and productive at the date of the report, and gives evidence that the vines had grown successfully for 80 years prior to that date. It brings the record of prosperous vine-growing down to the date when the vines at Anaheim were planted; and it shows the successful starting of these vineyards. That they were still in bearing and, in the main, in a thrifty condition just prior to the appearance of the disease is evinced by the fact that they still in a great majority of cases occupied the ground, as shown on Chart II of this Bulletin.

Mr. Wilson Flint, in a paper published in the Transactions of the California State Agricultural Society for 1859, says that "no risk can be run in planting largely of the California Mission;" and further that "the Mission grape seems to be peculiarly adapted to this climate, as it is a very strong grower and will make a good stock to graft the more feeble foreign sorts on." We have here evidence that such a thing as climate causing a wholesale death of vines was unthought of in 1859.

In 1862 Hittell gives details of large vineyards in southern California as follows:

	Vines.
John Rains, Coco-Mungo	165,000
B. D. Wilson, San Gabriel	100,000
Wm. Wolfskill, Los Angeles	85,000
Mathew Keller, Los Angeles	61,000
T. J. White, Los Angeles	50,000
J. R. Scott, Los Angeles	50,000

He also informs us that the towns most notable for the cultivation of the vine in California at that date were Los Angeles, Anaheim, and Sonoma, "all grape towns, which depend on the grape for their revenue." Los Angeles had 900,000 vines; Anaheim, 400,000 vines; Sonoma, 500,000 vines. Many of the vines of Sonoma were not old enough to bear. Those of Anaheim were in their fourth year, while more than one-half of those at Los Angeles had been in full bearing for several years.[1]

In 1870–'71 John A. Lockwood refers to the accepted idea of the hardiness of the Mission vine. He says that the Mission or California vine claims the first notice as the earliest known and the most widely cultivated. It is of hardy growth, exempt from disease and accidents; it makes good, sound, well-keeping wine, and yields abundantly of spirit, because of its great sweetness.

In 1879 Hon. J. V. Webster, in an address before the California Agricultural Society, stated that there were then about 60,000 acres of vines in California.

About the time of the wholesale death of vines in the Santa Ana Val-

[1] Resources of California. Agriculture, p. 200.

ley Maj. B. C. Truman published an article in the New York Times on Anaheim. He says:

> One of the most interesting places in southern California, or, in fact, in the world that I have visited is Anaheim, about 28 miles from the city of Los Angeles. Wine-making has been, is, and always will be the leading industry of Anaheim. The light soil has been proved, by nearly thirty years of experience, to be well adapted for the successful growth of the vine. * * * It is well known that the Mission, Zinfandel, Black Malvoisie, Mataro, Trousseau, and Golden Chasselas are as successful there as in any portion of the State.[1]

In commenting upon the growth and prosperity of Anaheim, Mr. Lindley[2] says that during thirty years it has continued to be preëminently a vine-growing and wine-manufacturing town. There were, in 1886–'87, about fifty wineries in Anaheim and its immediate vicinity. He says the business of wine-making has always been in the hands of the German colonists, and they have made money steadily, almost from the beginning.

At the close of the season of 1886 the vines which had been counted in 1857–'58 by the thousands were to be counted by the thousands of acres in southern California. Los Angeles County, which then included the territory now set apart as Orange County, Mr. Truman informs us, had an area of 22,005 acres of wine-making grapes, from which nearly 5,000,000 of gallons of brandy and wine were made in 1886. There were a number of vineyards in the county from 70 to 80 years old and still in bearing. His figures show a total for the county of 25,705 acres of grapevines. Of San Bernardino County he says that five years previous it had 1,213 acres of vines, besides which it had, in 1886, 342 acres 4 years old, 320 acres 3 years old, 220 acres 2 years old, and 315 acres planted that year. These figures did not include about 100 acres of table and 1,700 acres of raisin grapes, which amount to 4,210 acres of vines all told. Thus there were nearly 30,000 acres of vines in Los Angeles and San Bernardino counties alone when the disease began to develop a short distance from Anaheim.

I insert here some notes from a letter of Mr. A. E. Maxcy, of Vineyard, San Diego County, which represents the present condition of the vines and gives some idea of the requirements of the Mission variety. In 1856 he planted 500 Mission vines. They were set on "made or wash" soil, a rich loam, and were 5 to 6 feet apart. They were watered copiously, but had insufficient cultivation. They were also too near together, but they yielded bountifully for ten or twelve years, after which they began to deteriorate in growth of wood and size of grape. The causes were, "Irrigation, want of cultivation, too many points, and consequent overproduction." They were dug up when 18 years of age. He planted a second Mission vineyard of 2,000 vines, one-fourth of a mile from the first. This was set in 1859 on rich, loamy soil. About

[1] Quoted in "California of the South," by W. Lindley and J. P. Widney. New York, 1888, p. 174.

[2] *Ibid.*, p. 175.

1886, when the vines were 27 years old, they began to show a loss in size of top. They were chopped off level with the earth and a sprout was raised from the stump as an experiment. At the time of writing, in 1889, it is said these sprouts had again become lusty vines, and that they would yield a large crop the following season. It is also said that "the vineyard was injured by irrigation, lack of cultivation, and too many spurs left in pruning." The third and principal vineyard set was on 15 acres of rich, washed loamy soil. They were Mission grapes planted in 1866. By this time Mr. Maxcy had learned to cultivate and not irrigate and to leave fewer spurs. He says: "This vineyard, now 23 years old, is in a healthy and fruitful condition." It received no water, but thorough cultivation. With respect to the product he states that his chief trouble is that they produce too much.

I will conclude by giving the dates of vine-setting and the names of the varieties as they appear on the plat of Anaheim, published herewith (Chart II). This is for the purpose of showing that vines of all ages prospered from the time of the first setting of the Mission vines at Anaheim to the appearance of the disease. The chart does not include all the vineyards of Anaheim, but it is thought to be sufficiently complete to show that all vines died at the appearance of the disease, no matter in what years they had been set or what the variety. The dates, in the order that vines were set, are as follows: 1857, 1858, 1860, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1874, 1875, 1878, 1880, 1882, 1883, 1885.

Taking 1887 as the average year of death for these vineyards, the age of the vines at the time of death ranges as follows: 30, 29, 27, 23, 22, 21, 20, 19, 18, 17, 13, 12, 9, 7, 5, 4, and 2 years. The varieties and dates when each was planted are as follows:

Mixed varieties, set 1860.
Mission vines, set 1857, 1858, 1860, 1864, 1865, 1866, 1868, 1874, 1884.
Zinfandel vines, set 1868, 1878, 1880, 1883, 1885.
Muscat vines, set 1867, 1868.
Black Hamburg vines, set 1882.
Berger vines, set 1868, 1869, 1875, 1878.
"Sweetwater" vines, set 1860.
Malvoisie vines, set 1870.

CHAPTER III.

SPECIAL CHARACTERS OF THE DISEASE.

THE LEAF.

As in the healthy vine, the size of the leaf varies according to its position upon the cane, is usually in direct proportion to the size of the latter, and is dependent upon its vigor of growth. As might naturally be inferred, vines in the second or later years of disease, when there is less vigor and consequently a shorter growth of cane, produce leaves smaller than those borne by healthy or recently diseased vines. On the other hand, there is very rarely, if ever, any such disproportionate reduction in the size of the leaf under the influence of this disease as is seen in the case of vines grown in cold or alkaline soils or affected by root fungi. In fact, the proportions of the leaf to the cane and top of the vine are, in general, so well maintained, that the reduction in the size of the leaf does not impress one except in later stages of the disease or by direct comparison. The petiole retains its proper proportions.

In a majority of the diseased vines, although not in all varieties, the leaf presents distinct characters. They may be mentioned as *constitutional* and *localized* characters. The localized characters are those of the leaf affected after it has become fully and perfectly formed, but only including the local effects of the disease. The constitutional characters are those of a leaf never becoming perfect—showing a diseased state from the time of its opening—or those of a matured leaf subsequently affected in a constitutional way.

The constitutional effects upon the leaf become apparent in two ways:

(1) The chlorophyll of the newly formed leaf fails to properly develop in that portion of the parenchyma lying slightly distant from the main fibro-vascular bundles, or in that part supplied only by the finer spiral vessels. Hence the leaf never assumes its normal green color, but, instead, has a stripe between each two principal veins or vascular bundles. In the white varieties (Muscat, etc.), as shown in Pl. XXIII, this stripe with its lateral prolongations between the secondary veins is first of a light greenish color, then yellow, and at last this tissue dies, to a greater or less extent, and the leaf drops. In the black varieties of grape, however, this immature region assumes a red rather than a yellow color before the death of the tissue,[1] and there may be dead

[1] There are some exceptions to this rule.

tissue with a border of two shades of red between it and the green portion. This early spring marking of the leaf is very distinct in the Flaming Tokay vines as well as in the Muscat.

(2) The chlorophyll forms as it should in the healthy tissue, giving the entire leaf a uniform green color. At a later stage, however, owing to defective nutrition, the chlorophyll of that portion of the leaf formerly described as being nourished by the finer spiral vessels loses its normal color, and the parenchyma changes gradually to yellow in the white varieties, and to red in the black ones. Following this we have the same successive changes as were passed through in the case described under the first condition. These changes of the leaf end in its death and fall from the petiole, as in the former case.

These general or constitutional effects are then due to a failure in the formation of chlorophyll, or degeneration of that once properly formed, in those portions of the leaf supplied by the finer spiral vessels. These general effects are found to some extent in nearly all varieties. They are clearly shown in the native species, and in the native and foreign varieties.

The localized effects upon the leaf are most clearly seen in the white varieties, and are especially characteristic in the Muscat. Although the leaf may have a natural green color over nearly its entire surface, one or more yellow spots may often be seen in that part of the parenchyma supplied with the finer spiral vessels. These spots are often well defined, the outline being very sharp and distinct. The fact that the tissue of the leaf in general is still to all appearance in its normal condition tends to indicate that the constitutional trouble is not yet sufficient to produce a general alteration or degeneration of the chlorophyll bodies, while here in isolated spots the yellow color is found in well defined patches, showing that the chlorophyll within those limits is entirely altered. These spots may become more numerous after a time and enlarge in diameter, until the general constitutional effect is very closely approximated. The leaf then falls as in that case. These spots involve the entire thickness of the leaf, being well defined upon both surfaces.

In leaves showing either or both localized and constitutional effects of disease, it may often be that the margin will die as soon as any other portion. It turns brown as with most dead leaves, and like the center of the dying regions between the vascular bundles. In this respect the leaf appears much like that affected with Peronospora in a dry climate. This effect is especially well marked in the dry salt-making regions of Marsala and Trapani in western Sicily.

VARIATIONS IN VARIETIES.

The *wild vine* of the cañons of southern California shows the markings of foliage characteristic of this disease (Pl. XXIV). According to Mr. T. V. Munson, this form is presumably not *Vitis Californica*. Wild

vines of this southern species were examined in large numbers, particularly in a cañon northwest of San Gabriel. On many the leaves were found to be badly spotted, and in some cases the stripes were well marked, giving a fern-leaf appearance, shown in the lower figure on the plate of Muscat leaves (Pl. XXIII). This same appearance has been seen elsewhere, especially in the cañons of the Santa Ana Mountains.

The *Muscat leaf* presents the characters of disease given in the preceding general description and those shown on Pl. XXIII. While speaking of this leaf, however, attention should be called to other appearances in the parenchyma, but which perhaps have no connection with this disease. There are often on the forming leaves of young vines (probably only more discernible upon this variety than upon the others), gathered points in the tissue about centers lacking chlorophyll. These spots are irregularly distributed over the leaf and resemble scars due to burns. In some cases the minute centers of these scars are colorless; in others the cells are dead and brown, and often the scar includes a considerable number of cells which have lost much of their normal green color. This looks like the work of some exceedingly minute parasite. It occurs on many young vines, but is not constant. The older leaves show signs of these dead centers, but they are of little importance in the larger and more mature leaves.

The *Isabella leaf* markings are typical, and the yellow points so common on the Muscat leaf are here also quite discernible. These spots become grouped or sprinkled through the tissue between the main veins, in some cases forming evident stripes, the tissue becoming brown and dying in the center of the spots or stripes. In some cases there are large isolated yellow spots as well as small ones. Another characteristic of the disease exists here in the alteration of the margin of the leaf, forming, in some cases, a very distinct yellow band around nearly the entire edge. Later on the margin turns brown and dies; so that there may be seen the green and yellow spotted body of the leaf surrounded by a yellow band about an eighth of an inch in width with a brown margin; or the brown and dead margin may be joined directly to the green body of the leaf without the yellow intervening band. In this last case there may be quite a width of dead margin, and this may curl upward more or less. The fern-leaf stage of the disease is, in this variety, more discernible on the newly formed terminal leaves. On these it is often well marked and very characteristic of the constitutional effects of the disease.

The *Black Malvoisie leaf* presents the following characters: On a strong cane, where the disease is not marked by dead leaves, its presence is shown by the green color becoming lighter between the veins. This change may occur in spots, but more commonly most of the leaf, excepting that bordering the larger veins, is involved; thus giving the fern-leaf appearance of the Muscat. This is often the first marked sign of the disease, and becomes very distinct in this variety. Later the tissue between the main lateral veins turns yellowish white in blotches

or stripes, and the yellowish color in turn gives way to a whitish shade with a red center, forming well-marked red blotches commonly uniting into stripes. The red of the stripe is usually bordered by a whitish band that is followed by green at the veins. The margin of the leaf is usually marked with red at this stage, and soon begins to turn brown and die, the dead portions extending inward through the center of the red stripes.

In *the Traminer* the markings are very prominent. The leaf is marked in a similar manner to the Jacques (Pl. XXI). There is a broad yellow border and broad yellow stripes between the veins, not running into a dead center at the season they were observed, August 7 and later. The green is uniform, and there is no shade of red or anything approaching red in the stripe. The yellow is light and the green dark, and the line of demarcation between the two is very abrupt.

The *Blue Elba* leaf is affected very much as the Traminer and Jacques leaves (Pl. XXI). One might suppose these three varieties very closely related. The Blue Elba leaf differs from that of the Traminer in having a narrower yellow border and in possessing superficial fine red blotches upon the yellow bands between the veins, the latter appearing more like highlights than an alteration of the entire parenchyma. The narrowness of the marginal yellow does not give it the appearance of a band, as is the case with the former variety.

The *Klaeber leaf* is marked with yellow in the fern-leaf pattern, not having the broad marginal band of yellow as in the Jacques. The markings much resemble those of the Muscat leaf.

The *Flaming Tokay* has a highly colored leaf. A colored representation of the leaves of this variety is given on Pl. XXII. One observation respecting the markings on the leaves of this vine is of interest. In a vineyard near Santa Ana, where the stock was pruned high, as is also customary with the Mission vines, I noticed that the first leaves of the spring growth were highly colored, like autumn leaves, while a later growth was green and normal, and retained its color much of the season. Toward the latter part of the heat of the season this also began to change. The red of the Tokay leaf is strongly marked.

The *Mission vine* has a highly colored leaf somewhat resembling the Tokay leaf in its markings. Many of the Mission leaves die, however, without showing these characters, and this may also be said for nearly all varieties.

The leaf of *the Trousseau* shows red blotches at the margin as soon as the disease is well advanced. The tissue between the veins becomes yellowish in spots, afterward turning to a wine red. The margin, partially or entirely, gradually becomes tinged with red, which extends further and further inward. The tissue dies from without, the deepest color being toward the margin. In some cases, especially on young leaves, the tissue loses its color in a general way, giving the fern-like appearance so common in this disease.

In *the Riesling* the leaves often become curled, present light spots, but die as a whole or in an irregular manner, not showing stripes as with Muscat leaves.

The leaf of *the Charbono* curls somewhat, and dies around the margin or on one side. It shows the fern-leaf pattern faintly, and some leaves are a little spotted.

The *Berger leaf* rarely if ever becomes distinctly altered in color as with the Muscat. The death of the leaf is quite general and rather sudden, and it may become somewhat curled like an ordinary dying leaf.

These descriptions are sufficient to show the variations between the varieties of grape leaves. The spotting and striping of the leaf is a character which generally accompanies the disease.

It should be noted that where death is rapid the leaf is not so apt to show the markings of disease. It is hence usually the lingering, though not of necessity the more hardy vine which will show most characteristic markings upon the leaf. The distinction between the diseased leaves and those dying from ordinary seasonal or other well-understood influences should be noted. The most distinctive characters are two:

(1) The sharply defined yellow or red spots, involving the entire thickness of the leaf.

(2) The death of the tissue far in between the larger veins, while the latter still remain bordered by narrow bands of normal green parenchyma.

The amount of spotting on the leaves of a single cane varies from the tip of the cane to its base, the basal leaves being more spotted than the terminal ones. This is sometimes strongly marked. We find all stages of disease, from faintly spotted leaves at the growing extremity through strongly spotted and striped leaves in the middle to dying and ragged ones at the base of the cane. This is well shown on Plate XII, which represents a "short growth" about 12 inches long produced by a Muscat vine at Orange, and is a typical illustration of these facts. As a rule the leaves fall from the base of the cane first, because the disease has advanced further in these leaves than in the distal ones. In a large percentage of cases the leaf separates from the distal end of the petiole, thus giving a singular appearance to the denuded vine, though it is of short duration, as the petioles soon fall. It much reminds one of the falling of the leaves of Ampelopsis. In the Rose of Peru variety the clinging petioles dry up and turn black at the free end. Death progresses from the end, and this becomes somewhat bent before the petiole falls.

On the ground-shoots or "suckers" the leaves follow the same order of marking as upon the normal canes, but the disease begins later because the shoots are a later or secondary growth. In a badly diseased vine—say a Muscat which has shown disease for two or three years—these shoots usually appear much more healthy in their foliage than

the remainder of the top. This is not a permanent improvement, however, for the following season the sucker shows disease in its leaves and dies as the other portions of the plant have done, although somewhat later and more slowly. The degree of health apparent in the leaves of the sucker depends largely on whether the shoot originates from new or old roots, as well as upon the condition of these roots. It is also an interesting fact that the degree of disease shown by these ground-shoots is less the lower the shoot originates on the vine. Observations illustrating this fact are given here which were made on vine tops newly formed from ground shoots. A Muscat of Alexandria vineyard near Orange was examined on August 28, 1889. It was located on the gravel land northwest of the town. The vines had become worthless from the effects of the disease, and on attempting to remove them a large number had been broken off above or just below the surface of the ground. This was done previous to the summer of 1889. When examined in August a large number of these broken stocks had sent up shoots, and these new shoots afforded a good opportunity to compare the amount of disease in ground shoots and those coming from above. Out of 100 vines examined as they were found in the field 80 had tops from below the ground and 20 had a portion of the old wood above the surface. Of the new tops arising just at the surface of the ground 45 per cent were apparently healthy and 55 per cent diseased; while out of the 80 tops from below ground 80 per cent were apparently healthy and only 20 per cent diseased.[1]

THE CANE.

Most of the results of disease seen upon the cane may be described from the Muscat as a type. The length of the cane is usually determined by the degree of the disease and its position upon the stock. The more advanced and prolonged the disease in the stock the more limited the growth; and, as a rule, the nearer the shoot originates to the root of the vine the more thrifty it is. In an advanced stage of the disease the internodes become shortened. A diseased cane only 13 inches in length, and which represented the greater portion of a year's growth, had ten nodes and ten internodes.

The cane usually becomes bare of leaves before the wood is properly ripened. The end of the cane, being last to ripen, is most immature, and soon after the leaves fall the unripened parts turn black and become dry. This progresses more rapidly and the dying is more complete when the leaves drop early, before the fall rains, for the atmosphere is dryer and more heated and evaporation is greater and more rapid at that season.

The peculiar and unequal ripening of the cane is very marked and is

[1] "Healthy" and "diseased" are here used in the relative or comparative sense. Those plants showing badly mottled leaves were classed as "diseased," while those nearly free from spots were classed as "healthy."

well shown in Plate XXV. The properly ripened cane should present a cinnamon-brown color nearly to the extremity. In diseased canes it is common to find the terminal third entirely green after the fall of the leaves and the other two-thirds ripened in an irregular and characteristic manner. The amount of properly ripened wood usually increases toward the base of the cane, but even on these portions the ripening is not as complete and entire as it should be. On the internodes there are often patches of unripened tissue in the center of the properly ripened portion; or similar patches of ripened tissue surrounded by that which is unripened. Again, one side of the cane may be properly ripened and the other perfectly green. Left in this condition at the beginning or the close of September, there is soon a marked shrinkage of the green portions and an alteration of color. Toward the end of the cane the entire cortex, from the cambium to the epidermis, shrinks tight upon the xylem cylinder, often so as to show longitudinal folds or ridges. The cortex at last becomes perfectly dry and black, while the drying involves the wood as well. At this time the end of the cane can be snapped off between the thumb and finger. This may be done further and further down the cane as the drying continues. Death and shrinkage also take place toward the base of the cane, but more slowly, and owing to the size and properly ripened portions it can not be so easily broken. In the half-ripened basal portion the demarcation between the ripe and the green wood is well defined and shouldered, and the dividing line becomes blacker or darker than the body of the unripe wood. This gives a peculiar character to many of the diseased canes, a black line following the edge of the ripened wood. This is also seen at the limit of blighted twigs in the case of pear blight. In the dried portions of the grape cane the bark adheres closely to the wood.

On canes which are not cylindrical the flattened side is the one most commonly found green at the fall of the leaves, and is therefore most apt to present a blackened appearance. It is claimed that there is a marked flattening of the cane due to disease, but I am not yet satisfied as to its extent. Even in healthy vines canes are often found which are flattened on one side, and any apparent increase of this in diseased vines may be simply due to the stoppage of growth by the premature fall of the leaves.

A macroscopical examination of the interior of the cane shows a premature discoloration of the pith cells, which precedes the discoloration of the wood. The following are special characters shown by a few varieties.

Isabella.—The growth of the canes examined was short and slender and they were limited in number on the vine. Imperfect ripening of the wood of this grape is observable as in *vinifera* stock, but it is rarer and less evident. Green sections are found between ripened portions, the line dividing the green from the ripe becoming black and shouldered. The internodes near the end of the cane are rather short, but this is not a prominent character.

Berger.—Owing to the rapidity with which this vine succumbs, it presents an abundance of dead and blackened canes. The leaves fall while the fruit is still on the branches, and while the new wood is quite immature, leaving the latter to blacken and die throughout the greater part of the cane.

Rose of Peru.—The vine from which the cane described was taken was from the vineyard of George Heberle, near Norwalk. The entire vine was rapidly dying. Most of the leaves about the center of the vine were already dead. The grapes had shrunken and many had fallen off. This cane was cut slightly above the old wood, and is 6 feet in length. It is composed of twenty-nine internodes varying in length from 1¼ to 4 inches. The diameter of the cane at the base between the joints is one-half inch; and at the center of the distal segment slightly more than one-sixteenth of an inch. At 1 foot and 1½ feet from the base are lateral canes, slightly more than a foot long. All the leaves but one for 4½ feet from the base are shed (August 29, 1889); while they still remain on the terminal 1½ feet. Nearly all the fallen leaves have separated from the petiole, leaving the latter clinging to the cane. This fact also holds good for the two lateral canes, which have shed their basal leaves and retained the terminal. The leaves have fallen from the entire vine in the same manner. Of the leaves remaining those nearest the growing point are most healthy, so far as markings are concerned. The most striking feature of this cane is its green color while nearly denuded of leaves. The only ripened wood reaching as far as one-half inch from the joint is upon the first nine segments of the cane, which do not extend more than 2 feet from its base. On these basal segments the wood is very irregularly and only partially ripened, and there is no apparent regularity to the ripening. The maturing color occurs on all sides and in this case more nearly covers the seventh segment than any other, while the second and third basal segments have but little ripened wood on them. The old wood, as is usual, ripens before the new. More commonly in normal canes the wood ripens from the nodes first, but here on segment six a ripened spot occurs on an otherwise green segment. The two tendrils borne by the cane are dead and dry to the point of attachment. The cane being split from end to end shows the pith of the first 30 inches—twelve segments or joints—badly discolored. Less discoloration exists toward the extremity. There are cases where the unripened basal parts of the cane become dried over exteriorly so that they are hardly distinguishable to the eye from properly ripened wood, though the color is too dark in most instances.

There are cases with some varieties where the cane will continue to grow with the terminal leaves after the basal leaves have fallen from disease. This may occur late in the season or after a rain. It seems like an effort to mature the terminal wood; and gives the vine or vineyard a strange, plumed appearance.

THE BODY.

It has been claimed by some who have made a study of the disease on the old Mission vines that they are diseased first on the southwest side. Knowing that trees are often blighted upon that side more than upon others, I wished to see what grounds there were for holding that vines were so affected. During the field work a large number of vines in Muscat vineyards of medium age were examined. In these cases there was no external evidence of a blighted condition upon one side more than another. A vineyard of Mission vines at San Bernardino, not less than twenty-five years of age, was also examined, and there the blighted condition of the stock on the south side was very apparent. But this blight was not new. It had evidently been the result of many years of exposure to the heat of the sun and the action of water. The considerable decay of the wood and blighted condition of the bark clearly antedated the appearance of the disease in that locality in 1887 by many years,[1] not less than eight or ten. These effects could not be assigned as the cause of the disease. The vines were growing on a rich, black, adobe soil, with a sandy intermixture. No case of recent blight was observed except where some of the stocks dying from disease had become dried out and cracked open. About the edges of the blighted spots the bark had become rounded off and the scar was partially healed over, showing that the death of the original bark had taken place years before. Further than this, these blighted places had no direct connection with the disease, as dead vines were found which were not blighted, and badly blighted vines were found which were not, comparatively, badly diseased. It is true these blighted places run from the top downward, but this fact may have a natural explanation. All vines pruned after the manner of vines in southern California admit more or less moisture into the stock through the closely pruned spurs. In an examination of split vines made in the vineyard of Mr. M. Nisson, near Santa Ana, this is shown to be the case by lines of dead cells extending from the injured and cut spots at the top of the vine. These lines extended down a greater or lesser distance through the wood according as much or little moisture had entered at the exposed surface. In every case, or nearly so, where dead cells are found, as here described, their presence may be traced to some injury or defect upon the outside of the vine.

In the following record it will be observed that the greater number of vines were blighted on the south or southwest side, or that exposed to the greatest heat of the sun. The 100 vines examined were a fair representation of the whole of the vineyard.

[1] What I term "blight" is the death of the bark and often a much decayed state of the wood showing exteriorly.

Blight of Mission vine trunks—Number of vines and sides affected.

N.	NE.	E.	SE.	S.	SW.	W.	NW.	Number blighted.	Number unblighted.	Total.
(*)	4	3	5	22	16	5	1	56	44	100
		& S. 1		& N. 2	& SE. 1					
				& W. 1						

*See under "S."

It will be seen that one vine blighted on the east was also blighted on the south side; two were blighted on the north and one on the west which are also recorded for the south; and one was blighted on the southeast which was also blighted on the southwest side.

In order to learn the condition of the wood of the affected vines 25 Muscat vines on the place of Mr. Nisson were split open and carefully examined immediately after their removal from the ground. Nothing was found that could be called especially characteristic of disease, except that the wood of badly diseased vines contained less sap than would have been the case with a healthy vine under like conditions.

The following statement gives the results of the examination made in the Nisson vineyard. The examination was made on September 9, 1889.

Examination of diseased vine trunks, Nisson vineyard.

	Number.
Vines split	25
Infested by termes[1]	2
Sapwood decaying	6
Top of trunk decaying	7
Most sap above	0
Most sap below	20
Sap equal above and below	4
Wood rotten above	5
Wood rotten below	0
Wood (brown) colored above	7
Wood (pink) colored below	23
Dead cells in wood	22
Pith evenly decayed	21
Pith most decayed above	4
Pith most decayed below	0
Pith living	0
Pith dead	25

The wood in all these vines, which were just in their prime, was sound and had a general appearance of health. The lines of dead cells mentioned, as well as the dead pith, are apparently due in greater part to

[1] Termes were found in only one stump, but another stump was badly eaten into, without doubt by these neuropters.

the introduction of water and air through external injuries in the stock. Where the body of the vine is very long, or where it has large and long branches or runners supporting the annual canes, the more advanced and earliest signs of disease are to be seen near the end of these main divisions. This is another way of saying what is said under the head of the degree of disease in canes, *i. e.*, that the canes nearest the ground or root of the vine look most healthy and die latest. In the trunk of a long vine these facts are often very strongly marked. In a vine of 30 to 50 feet in length the extremity may be rapidly dying while the basal portion shows no external signs of disease. On July 4, 1889, at the Wolfskill residence, in Los Angeles, I saw a Mission vine probably 40 feet long trained on a porch and across the west end of the house at the cornice. This vine was in its prime and had heretofore been healthy. I noticed that the end was dying, although most of the vine appeared healthy. This place was visited again on October 10, 1889, and the vine was found to be badly diseased throughout its entire length, and hanging full of shriveled grapes.

Decay of the body of the vine does not usually occur until after the death of the stock. The decay of the larger roots will eventually attack the trunk, however, and in some cases the latter becomes so badly rotted as to be kicked over without difficulty.

THE ROOTS.

The time when the root first becomes diseased is difficult to ascertain, and probably will not be known before the nature of the malady is determined. It is even uncertain whether external signs of disease may be seen first upon the root or the top of the affected stock. Many vine-growers who have had experience with the disease believe the root becomes affected last, but this question is difficult to decide. At present I incline to the opinion that the extremes of the vine show the early signs of disease at nearly the same time, whatever part may be its true seat.

To ascertain the course of the disease in the root a more or less thorough examination of the root system of several hundred vines has been made. Several varieties and various ages of the vine have been included; and the examinations were made in many localities and at different seasons of the year. The greater number of those vines examined had just been removed from the earth by pulling, which often removes a large part of the root system. To supplement this I have, at different times, personally removed the earth from many vines, in various stages of disease, with the object of determining the effects of the disease upon the growing point and terminal root fibers. Abundant alcoholic material has been preserved and numerous microscopical studies have been made.

Among the first signs of disease is a discoloration and shrinkage in diameter of the finer root fibers, the root hairs and cap. This progresses

until the tissue begins to decay. The epidermis becomes wrinkled longitudinally, and has the appearance of being altogether too large for the root. Later on these creases deepen, and the entire epidermal sheath becomes loose and flabby. The finer rootlets die entirely, and the ends of the larger roots die back. When decay begins the cortical parenchyma begins to break down next to the vascular bundles, and finally the bark of the root becomes so free from the contained bundles as to slip freely from the latter when drawn between the thumb and finger. From this time decay progresses steadily from the ends of the rootlets back to the main roots, following these little by little to the trunk of the vine itself, if the latter be not first removed.

On January 9, 1890, I examined the root system of over 100 Muscat vines 7 or 8 years old, just as they were being taken from the ground in the vineyard of A. L. Bearing, near Santa Ana. The roots were all rotting from the extremity, and their condition may be shown by the description of a single vine. This had ten roots springing from the cushion at the base. Of these all but one were badly rotted to within a few inches of the body of the vine, and this one was rotted some distance from the cushion. Above the cushion were twelve other roots, nine of which were badly rotted close to the body of the vine, two were broken short off, and the other at 6 inches from the body. The three broken roots were the only ones which could have in any way supported the top. This made not more than four comparatively healthy roots on a vine having at one time twenty-two fine, fair-sized roots. On this vine was a growth of thirteen canes from 1 to 5 feet long, most of them being only partially ripened.

It sometimes occurs that roots rotted near the trunk of the vine have sound and seemingly healthy portions farther toward the extremity. I can only account for this by supposing that some lateral root was decayed back to the larger root and infected the upper portion before it had been reached by the decay progressing from the extremity. It is interesting that the rot of the root is in a majority of cases a wet rot. No matter how dry the soil or hot the season the decay between the xylem bundles and the epidermal layer is saturated with water. This is more apparent in the small and medium sized roots than in the larger ones.

The protective system or epidermis of the root is all of the cortical portion which remains sound and united, and it may be easily drawn from the xylem cylinder much as a glove from the hand. Where vines are pulled from the ground by mechanical means this cortex is left in the earth for the greater length of the smaller roots; in many cases only the bare, wet, and flexible xylem cylinder is drawn out by its attachment to the main root. The fundamental tissue composing the rays also becomes decayed, thus separating the vascular bundles from each other. At this stage of decay of the smaller roots, by slight pressure the xylem cylinder may be easily separated into its constituent bundles,

and these often resemble the untwisted and straightened strands of a rope.

The root, at last becoming wholly rotted, passes into a brown, loose, amorphous mass. A microscopical examination of the decaying outer parts of the vascular bundles shows that the cell lumen is filled with a translucent amber-like deposit. This persists after the decay of the cell wall, and presents rod-shaped, more or less irregular and eaten, amber-like casts.

THE FRUIT.

If the first attack of the disease be violent the grape will sometimes fall from the bunch. This dropping of the fruit is not so strongly marked and is less important than the drying of the berry upon the bunch. As mentioned elsewhere, the Anaheim Gazette stated that vines which had appeared healthy three weeks or a month before July 24, 1886, were then beginning to shrink and dry, and the berries were dropping off. This seems to have been particularly true of the Mission vines, although some foreign varieties were similarly affected, but in a lesser degree. In Mr. Heberle's vineyard, near Norwalk, on the Rose of Peru vines which were rapidly dying of disease in August, 1889, but which had been well loaded with fruit, the grapes were much skrunken and many had fallen. One season's work in the field has afforded little opportunity to observe the dropping of the fruit due to this disease. In some cases the growth of the berry is retarded. This is well shown in the Golden Chasselas (Pl. VII). The diseased and normal bunches were gathered at the same time from the Gerken vineyard near Orange.

The drying of the fruit upon the vine is a leading effect of the disease and is very general in all varieties and under all conditions. I give three plates showing striking cases of these dried grapes, though it is only what is met with on all sides in the district where the disease prevails. On one plate (Pl. VI) are grouped two bunches of Berger grapes of about equal size. One bunch is dried from the effects of the disease and the other is in a normal condition. Both bunches came from the Berger vines of Mr. F. Gerken, near Orange. On another plate (Pl. VIII) are shown two bunches of grapes dried from the effects of the disease. The larger of these two bunches is of the Jacques[1] variety, from Mr. Langenberger's vineyard at Anaheim, and shows the effect of the disease upon the fruit of one of the hardiest American vines, a vine prized highly in France and quite largely grown in the western Gulf States. The smaller bunch of grapes shown is from the wild vines in a cañon northwest of San Gabriel, and is given as showing the effects of the disease in the native California vine of the southern counties. The third plate spoken of (Pl. III) represents a Berger vine, from the vineyard of Mr. Gerken, above mentioned, which had appeared healthy till

[1] "Jacques," "Lenoir," and "Black Spanish" are names applied to one variety of vine.

near the time of the vintage. This vine, like the others of the vineyard, was heavily loaded with fruit. I dug it up on September 19, 1889. At that time nearly all the leaves had fallen and the fruit had become almost perfectly dry upon the stems. The vine had twenty-five large-sized bunches dried upon it. In drying the berry shrinks as in the case of the ordinary sun-dried grape, but as there is but little pulp it becomes dry and quite hard, unlike an ordinary raisin. The drying is unlike that produced by artificial heat. At Duvivier, Algeria, I saw a vineyard injured by forest fires, and the effect upon the fruit was decidedly different from that produced by the drying out of the vine through the action of this disease. The immature grape does not harden and burst open under the action of this disease, as is the case where it is attacked by *Uncinula*. Cases occur where grapes become prematurely ripe; and the apical grapes of a bunch may become dried before those at the shoulder.

The effect upon the fruit which arrives at maturity is a loss in size, weight, color, sweetness, and pulp, or proper raisin qualities of the grape, if of the raisin varieties. The less the vine is diseased the better is the quality of the raisin. Dr. J. D. Chaffee, of Garden Grove, says that in his old Muscat vineyard the grapes and raisins were not much if any more than one-half as large after the appearance of the disease as before. It is also said that the diseased grape shrinks more in the process of raisin making. Experienced wine and raisin makers in the diseased district say there is decidedly less sugar in the must and in the raisins from the diseased grapes than from the healthy ones.[1]

Decay of the berry often occurs on vines which have been affected by this disease for a considerable length of time. In one small vineyard, which set a moderately good crop of fruit, not 100 pounds came to perfection on account of the decay which set in before the picking. In fact, this vineyard became strongly offensive on account of the decaying fruit. There was no uniform cause for the rotting except the effects of the disease, and the fact that this particular variety, the Flaming Tokay, will rot quite easily under ordinary circumstances on account of the compactness of its bunches.

After the disease becomes observable the vines produce less and less fruit each succeeding year. Just before the vintage I have walked for over a half mile through a vineyard diseased for three years and not found perfect bunches of grapes in sufficient numbers to satisfy the appetite of one individual. The fruit of such a vineyard is often very imperfect.

[1] There are some exceptions to this belief, however. Mr. Mirande, of Pomona, holds that there is no difference in the amount of sugar. This is contrary to the observations of others. It is quite generally accepted in the raisin districts of the Santa Ana valley that diseased Muscat grapes fail to make raisins of first quality and body. Mr. W. G. McPherson says he knows the sugar of diseased grapes to be less than that of healthy ones "by the taste of the grapes, but more especially marked in the coarse wrinkles and shrunken appearance of the raisins when dried."

THE SAP.

It has been noticed by nearly all who are familiar with the action of this disease that it is in some way connected with a reduced quantity of sap. This fact has been especially noted by those who have pruned the vines. For example, Mr. Peter Ainsworth, of McPherson, who has been in the habit of doing his own pruning, said he had observed a lessened flow of sap in the diseased stocks. At Anaheim some of the pruners became expert enough to foretell the death of the vine by the dryness of the wood, although it had been comparatively healthy the previous season. Mr. M. C. Cuddeback, of Orange, said that in cultivating healthy vines he observed that when some part of the body of the vine is broken off the sap flows out so as to wet the ground about the vine, but that when a diseased vine is broken in the same way and at the same season very little or no sap is seen to flow.

It has already been shown that where the vine is split longitudinally much more sap is found near its roots than toward the top. This explains why ground shoots are more thrifty and healthy than canes springing from the upper parts of the vine, and also why the diseased vine seems to be constantly making an effort, if the expression be allowable, to reduce the distance between the roots and the leaves.

In order to show the deficiency of sap, and to ascertain if possible whether peculiar features of flow exist in diseased vines, I cut back five stocks each of Flaming Tokay, Malvoisie, and Muscat, just above the ground, and observed them with care. The Muscat vines, in the vineyard of Mr. M. Nisson at Santa Ana, were 3 to 4 inches in diameter and the top showed from 10 per cent to 50 per cent of the normal vitality remaining, the average vitality being 27 per cent of that of a healthy vine. The cutting was done between 9:53 and 10:21 a.m., on September 13, 1889. One hour and twenty-four minutes elapsed before sap started in the first vine, and one hour and thirty-seven minutes before the second started. The three remaining had shown no signs of a flow at 5 p. m. On the morning of the 14th of September a third stump was wet, while the other two were dry.

The Black Malvoisie vines were 2 to 4 inches in diameter, and were cut off on the same day as the Muscats, and were in the same vineyard. The time was between 11 and 11:15 a. m. The vitality percentage of the top varied between 20 per cent and 60 per cent, the average being 35 per cent. At 12:10 p. m. no sap had started, but on the morning of the 14th four showed wet stumps.

The records obtained from the Flaming Tokay vines in the vineyard of Mr. Minter, near Santa Ana, are in all respects similar to those of the Muscat and Malvoisie vines.

The conclusions which may be drawn from these and several other series of observations respecting the supply and flow of sap in diseased vines are as follows:

(1) The amount of sap in the diseased vines is much less than in

those not diseased; (2) the flow of sap is much slower in the diseased than in the healthy vine; (3) when diseased, the last part of the vine to retain a fair amount of sap is the stock below the surface of the ground; (4) there is some evidence that sap flows more readily on the northern side, at least in diseased vines.

DISEASE IN NEW GROWTH.

In conducting experiments to ascertain the seat of the disease some interesting observations were made on vines that had been pruned to the stump. The vines examined were the Black Malvoisie in the vineyard of Mr. Nisson. About the 9th of September, 1889, the canes of the entire tops of these vines were cut off close to the body. Six weeks afterward, on October 21, when new growth had set in upon most of them, a careful study and record of 100 vines were made. These vines stood together in the field, and were selected as representatives of the vineyard. Out of the 100 examined 29 had failed to grow, while the remaining 71 had started, some having a leaf or two and others short canes. Going carefully over the 71 vines, 65 were found to show signs of the disease, while the remaining 6 were doubtful. The determination of the presence of the disease was largely based on the appearance of the leaves. The most general defect was the failure to form chlorophyll between the veins, leaving the light stripe or red markings common to the constitutional effects of the disease. The appearance was certainly that which might be expected to follow diseased and deficient nutrition, but seemed rather more pronounced than would arise from a reduced flow of sap. This, however, is still a matter of doubt.

In another series of experiments of the same nature, on the place of Mr. Hager, northwest of Orange, the same or similar results were obtained. The new growth, in this case on Muscat vines, showed the markings of the disease, mostly of the constitutional character. The presence of the peculiar markings of the disease in new growth induced by close pruning of the diseased vines in the growing season is only what is often seen on the new spring growth. Were this new growth on summer-pruned vines allowed to remain it would be found to be stunted in most cases, and the stripes between the veins would in time become more pronounced. In other words, the chlorophyll fails to form in many cases no matter how much time be given the leaf for its development. This shows a distinct difference between new leaves on diseased vines and those which are simply light-colored on account of their youth and immaturity. As has been already said, the new spring leaves of diseased Tokay vines may come out with as bright red and yellow coloring as any autumn leaves. Everything points to an abnormal state of the sap in the body and roots of the diseased vine.

INCUBATION OF DISEASE.

Under this head I will speak of the slow progress of the disease in the vine prior to its development to an obvious or distinctly injurious extent. Incubation may be here defined as that progress or effect of the disease which can be shown to be real, to have been felt by the vine, and yet of which the owner of the vineyard or anyone else may be wholly ignorant. It is an effect the ultimate results of which are sometimes capable of being foretold with some degree of accuracy.

In the affected district it is common to find a vineyard of one variety looking perfectly healthy and the adjoining vineyard of another variety badly affected or killed by the disease. It may be that the vines are of the same age and upon like soil. When we see a sharp line of this kind drawn between varieties it is folly to say that the disease has affected one and not the other, for it may occur that the dying variety is found on all sides of the living one. It must be admitted, then, that the disease has produced its effect upon vines not yet showing those effects.

It is also common to find a few Mission vines scattered here and there in vineyards of other varieties, they having been planted through oversight and the mixing of cuttings. Where this has been the case these Mission vines have been singled out and killed by the disease as surely as if they were by themselves in adjoining vineyards. It can not reasonably be held that the disease has alone touched these scattering vines and not affected those on all sides. The truth is that all the vines have felt the same influence of disease, but on account of difference in hardiness some show this influence earlier than others. Over the entire affected region the old Mission vineyards were first killed. For miles the Mission vines were dying among other vineyards which were bearing and apparently in perfect health. Those who were there at the time will recall the fact that this death of Mission vines was remarked by those who opposed the making of wine and the growing of the wine grape. It looked at one time as if the Mission or leading wine grape of the region was to be the only one killed, and that the Muscat or raisin grape was to be spared. This is an illustration on a large scale of the incubation of the disease. Everyone now knows that the Muscat vines have died in the district first affected as generally and surely as the Mission, and it can not be maintained that the disease was only present among the Mission vines when these other vineyards were interplanted in all directions, though not showing disease at the time. The explanation is simple. All vines were attacked, but the Mission vine, being more easily affected by the disease than the other varieties, died first. It showed disease long before the more hardy varieties.

This idea may be brought out in another way. Mr. F. Gerken had a Berger vineyard which was apparently in good health up to the last of the season of 1889, and was loaded with fruit that year. On adjoining places, and many other places in the neighborhood, vines had died in

former years. This vineyard had produced its usual crop in former years. We will say, for illustration, and which was the case, that many vineyards of other varieties of grape died in 1887 and 1888, but that this vineyard had maintained its productiveness. This shows that the Berger in that situation was capable of living and bearing and not showing disease for at least two years while the latter was present. In 1889, however, these apparently healthy vines suddenly "went back." The leaves fell prematurely and the fruit dried on the vine. From the fact that these vines did not die with others in 1887 we see that they could withstand at least one year of disease. When they had passed with seeming health through 1888 we see they could withstand two years of disease before it became manifest to the owner. This gives us good evidence that it was not the season of 1889 alone which killed these Berger vines, as two years of disease had already been withstood, but it was the combined effects of the three or more seasons of disease which at last killed them. We find, then, if we admit these facts, that the disease may be imperceptibly working and weakening a vine before becoming externally manifest by the vine itself. After noting the above-recorded effects of disease upon the Berger vines of Mr. Gerken I felt that I had to some extent comprehended the method followed by the disease. During the early part of the season (1889) I had visited Norwalk and examined the Berger vines of Mr. D. D. Johnston, as elsewhere noted. These vines were apparently in perfect health and were bounded by vines of other varieties showing disease. After the death of the Berger vines of Mr. Gerken I felt sure that those vines had also passed through the required period of incubation and would now show the disease. I wrote Mr. Johnston on November 20, 1889, and he replied under date of November 23 that the vines had in many cases behaved as had those of the Gerken vineyard. The leaves fell prematurely and the fruit dried on the vines.

It is not alone probable from the preceding facts that the disease has a period of incubation, but the productiveness of the vines attacked points to the same conclusion. Facts in hand indicate that there is overproduction of vines while the disease is incubating. Accepting the evidence I have gathered, the first effect of the disease upon the vine is stimulative, resulting in an unusual crop for one or two seasons prior to the breaking down of the constitution of the vine and the external appearance of disease. I am aware that all vine-growers do not hold this view, but thus far the absolute vineyard records of production appear to sustain it. That overproduction has not always been noticed is but negative evidence, and its well-attested occurrence in a reasonable number of cases is of more value than much negative evidence.

From the records of the Gerken and Johnston vines, as well as from observation in hundreds of other vineyards, we may say that the effects of the disease are cumulative. The disease may not be strong

enough to make itself manifest the first or the second year, but its effects seem to persist till the vine is ultimately conquered. Much evidence bearing on this point and strongly indorsing the idea that there is a period of incubation has been derived from the behavior of cuttings from diseased vines. It is shown under the head of the growth of cuttings that the time which the disease has affected the parent vine is clearly indicated in the subsequent life of cuttings made from it.

I wish to say here, from fear that I might otherwise be misunderstood, that I do not of necessity hold the disease to be constantly acting upon the vine because there seems to be a period of incubation. If there be an external parasite, that parasite may rest during much of the year. If there be an internal pathogenic organism, it may also have its period of rest. If the disease be due to climatic conditions, those conditions do not of necessity constantly hold sway.

In summary it may be said: (1) Vines appear to pass through a period of disease prior to the time the disease becomes externally manifest to the eye, a period of incubation; (2) this early period of the progress of the disease may be long or short according as the vine be hardy or easily affected; (3) the effects of the disease appear to be cumulative during the period of incubation.

CHAPTER IV.

THE LOCAL AND GENERAL DEVELOPMENT OF THE DISEASE IN SOUTHERN CALIFORNIA.

The review of the vine industry in Mexico and the Californias up to the year 1880, covers a period of upward of three hundred and fifty years, and there has nowhere been found any record of a general death of the vines such as has occurred since that date. Instances are found of the failing of vineyards from neglect or from improper care, as well as from decline due to old age. Various pests are mentioned as effecting the vine. Phylloxera has done serious damage in some of the more northern counties of California, but so far as we have been able to learn, there is here outlined for the first time a general, sudden, and complete death of vines over an extensive vine-growing section of this portion of the continent.

DEATH OF THE VINES AT ANAHEIM.

The first records of diseased and dying vines which have been found were published in the Anaheim Gazette in 1885 and 1886. That paper under date of October 24, 1885, says:

> The vintage is in its last stages. It has been much more satisfactory than anticipated; though it must be confessed that while some growers have cause for satisfaction, others can not greatly felicitate themselves. Although this was an off year for Mission grapes, there are many instances of large yields. The vineyard of Dreyfus & Co., on the south side of Center street toward the depot [1] yielded over six tons to the acre.[2]

It was not generally recognized that anything serious was affecting the vines until well along in 1886, as the following quotations from the Gazette will show:

> *October 25, 1884.*—The large increase in the production of grapes this year, caused by the facts that hundreds of acres of new vineyards contributed their first crop, taxed the wineries beyond their capacity. They were unable to work up the grapes as fast as offered and, as a consequence, the growers, especially those whose first experience it was, grumbled deeply and loud and prated of overproduction. They did not stop to consider the true cause of the glut; *i. e.*, that the wineries had not increased in proportion to the vineyards. There is no present danger of overproduction except in the growing of inferior grapes.
>
> *January 17, 1885.*—The vineyard area will be largely extended in the vicinity of

[1] See plat of Anaheim, lot "E-6."

[2] Mr. F. R. Krebs, foreman of the Dreyfus winery and vineyards for many years, informed me that this vineyard had commonly produced as high as ten tons of grapes per acre, but that in 1886, one year after the yield above reported, but one wagonload was gathered from the whole 18 acres.

Anaheim this year. The season promises to be favorable for the planting and growth of cuttings, and due advantage will be taken of this circumstance.

April 4, 1885.—Many vineyards are far enough advanced to give an idea as to the probable crop, and those who know are of the opinion that the crop will be a very large one, barring accidents. The vines are showing up wonderfully well under the stimulating and warm weather.

March 20, 1886.—The vineyards are leafing out and the season thus far has been favorable for the planting of new vineyards, and for the growth of old vines. But little, if any, irrigation has been required. The outlook is auspicious.

By July, 1886, the general and continued trouble with the vines was attracting attention. It had been discussed to such an extent that concerted action was thought desirable.

The Gazette of July 24, 1886, says:

Pursuant to the call published in the Gazette last week, a number of grape-growers met at Kroeger's Hall on Monday evening to organize a branch of the State Viticultural Society. * * * Following a discussion of grape-vine diseases, A. Langenberger and F. Hartung were appointed to correspond with Prof. Hilgard regarding the disease which has of late shown itself in many vineyards.

In commenting upon the meeting the editor says:

The uppermost theme for discussion at the present time is the disease which has shown itself for the first time this year among the Mission vines. In the early part of the season large numbers of vines (and trees as well) failed to sprout at all, while others sent forth a few sickly leaves which soon died. * * * It is worthy of remark that many of these vines are now sending out vigorous shoots, and we are told of an entire vineyard which is now in full blossom, a thing altogether unprecedented in the experience of the oldest grape-grower. On the other hand, vines which appeared vigorous and healthy three weeks or a month ago are beginning to shrivel and dry, and the berries are dropping off. This is true principally of the Mission vines, although some foreign varieties are affected in a lesser degree. In a 20-acre vineyard in North Anaheim there are but two Mission vines which were accidentally planted. These two vines can be detected at a long distance, their dried and yellow leaves being in marked contrast to the fresh green of the surrounding foreign vines. The affected vines are of all ages, in widely differing soils and in all kinds of localities.

The publication of the proceedings of this meeting in the latter part of July, 1886, may be taken as the first public acknowledgment of a badly diseased and dying state of the vineyards. But this was not the first appearance of the disease. The older Mission vineyards were so noticeably failing the preceding year that the Gazette had plainly stated that it was an off year for Mission grapes. In a section devoted largely to the growth of the Mission variety, as Anaheim certainly was at that time, an "off year for Mission grapes" was a poor year for a large percentage of the vine-growers of that immediate region. The disease was well marked in a large number of vineyards in the heat of the season of 1885, as nearly all now acknowledge; although, as the crop was saved, little notice was taken of the matter in the papers of that date. Chief among the reasons for the scarcity of published statements in 1885 was, undoubtedly, a lack of knowledge as to what was really foreshadowed by the failing of the vines and a natural desire to say no more than was necessary about a matter which would tend to depreciate real estate.

At any rate, we have had to depend mainly upon records gathered in the field for facts respecting any vine trouble in 1885 and earlier. The reliability of these facts has been carefully established and they are presented as authentic.

Mr. A. Bittner, of Anaheim,[1] dates the first appearance of the disease back to 1881 or 1882. His view was based upon his memory alone, and he was uncertain whether the year was 1881 or 1882. As this is the only record carrying the appearance of the disease at Anaheim back of 1884, it will not be used as a date until more evidence is advanced.

Mr. Theo. Rimpau states that the disease first appeared in his Mission vines in 1884.[2] It developed in a few of the older vines during the heat of the summer. Careful inquiry into this observation has failed to show any error of date, and as the entire vineyard died of the disease the identification is doubtless correct. Mr. Rimpau has resided at Anaheim since 1865, and on the lot where his vineyard was located.

Both Mr. Timothy Carroll and Mr. John Adams, who owned adjoining vineyards at the southwest of Anaheim, say they saw signs of the disease in the old vines in the season of 1884. Mr. Carroll, an experienced nurseryman of the place, stated that he had dug out 30 acres of vines in the fall of 1886.[3] He further says that although the vines showed some signs of disease in 1884, they came out well in the spring of 1885 and set a heavy crop of grapes. In June of that year the leaves began to curl, and toward the latter part of the season the grapes shriveled and the tips of the canes died. He says "the grape looked as if it wanted sap or water." This diseased condition, however, was not altogether general. The badly diseased vines came out again in the spring of 1886 and then died; while the portion of the vineyard lightly affected in 1885 came out well and the grapes set well, but in June and July they began to wilt and show a strongly marked diseased condition, and they were dug up in the fall.

The Rust place[4] was among those where disease was first observed in western Anaheim. In 1890 Mr. C. O. Rust wrote that he noticed the disease six or seven years ago, "but did not at the time think anything seriously wrong. My strongest and healthiest vines died the quickest. On the poorest land they held out the longest."[5] Although this date is rather uncertain it is important, as it is supported by records from adjoining vineyards.

Mr. F. A. Korn, who has resided at Anaheim for over thirty years, saw signs of the disease first on old Mission vines in 1885, when three vines in his vineyard failed to come out.[6] Mr. Korn's view is that the disease

[1] See plat of Anaheim, lot "D–7."

[2] See plat, lot "F–6."

[3] This was the first vineyard to be removed in the affected district.

[4] See plat of Anaheim, lot "B–6."

[5] Letter of February 11, 1890.

[6] See plat, lots "C–7" and "F–7." The dead vines were noticed on the east side of the latter.

developed during the winter of 1884–'85. In the fall of 1885 his vines showed their diseased condition by deficient and imperfect fruit. From facts gathered since these dates it seems certain that dead vines in the spring of 1885 indicated a diseased condition at a somewhat earlier period. Later observations have shown that a vine is nearly if not always diseased from one to three, and sometimes for five, years before its death. This would indicate that these vineyards were affected at least as early as 1884. They were composed of old vines of the most susceptible variety.[1] In a letter from Mr. Korn he says that the year before the disease appeared he found three dead vines in the outside row of the east side of lot "F–7" early in the spring; the vines were among the largest in the 20 acres. In the fall he "found twenty-five or thirty vines diseased on the southeast corner of the same vineyard, which were all dead the following spring." At a later date[2] Mr. Korn writes:

> The grape crop of 1885 was a good average crop, and nobody to my belief was expecting the vine disease in 1886. The disease came on in June, "like a thief in the night," and in less than a week it was all over Anaheim. The grape crop in 1886 was about half a crop, and in 1887 less than one-fourth. In 1886 I had on lot "C–7" a small average crop, and on "F–7" no more than half a crop.

Mrs. A. Frohling, at the northwest corner of the town,[3] had 33 acres in Mission vines. Disease was first noticed on a few vines in the spring of 1885, but it is thought it appeared in 1884.

These facts, a study of the workings of the disease at all points, and numerous records of dates taken from persons other than those at Anaheim, justify us in assigning the year 1884 as that in which the trouble gained its first decided foothold at Anaheim. The first observed effects of the disease appeared in the western portion and more especially in the vineyards at the southwest of the center of Anaheim.

Mr. Henry Kroeger, one of the older residents, states that he first noticed disease in his vineyards in the season of 1885.[4] Mr. A. Langenberger says he observed the first signs of disease on Mission vines in July and August, 1885. This was on the north side of Center street, a little distances west of his store.[5] The trouble was first noticed next to the road in the vineyard. At the place of Mr. C. F. Scholl,[6] in the northeast corner of Anaheim, the disease first appeared in 1885. Mr. Theo. Reiser states[7] that he had an old Mission vineyard until the disease made its appearance in 1885. The northern half of his place was planted with Mission grapes, but they had been replaced with Zinfandel

[1] Letter dated Anaheim, February 12, 1890.
[2] March 9, 1890.
[3] See plat of Anaheim, lots "A–7" and "B–7."
[4] See plat of Anaheim, lots "A–2," "D–1," and "G–6."
[5] See plat, lot "D–6."
[6] Lot "B–2."
[7] Lot "G–2." Letter dated February 20, 1890.

in 1880. They took the disease about one year later than the Mission. He says, further, that in 1885 the old Mission showed the first sign of disease, and that he had a small crop in 1886. In the spring of 1887 more than three-fourths of all the vines were dead and were soon removed. The Zinfandel held out one year longer.

Mr. John S. Hittell has kindly furnished me with numerous facts relating to the planting of his vineyard and the source of his cuttings. I have also a record of the arrangement of this vineyard furnished by Mr. Kroeger. Here the disease appeared in 1885. John Bach had a vineyard near the southwest corner of the town.[1] Besides the Mission vines set in 1857 there were two varieties of Riesling, two of Muscat, the Black Hamburg, and a long blue grape, all set in 1860 or 1861. All these varieties except the Mission were imported from Germany in 1856 or 1857 by John F. Stock, of San José. These vines resisted the disease longer than the Mission variety. North of the John Bach vineyard is another belonging to Mr. Henry Kroeger.[2] The vines here were mostly Mission and Muscat at the time of the disease. The Missions showed disease in 1885 and the Muscats in 1886. The former died in 1886 and the latter in 1886–'87.

The vineyard of Mrs. Metz, of Anaheim,[3] consisted of about 20 acres of vines near the center of the town. The vines were mostly of the Mission variety, but along the east line of the lot was a strip containing mixed varieties, among them the "Sweetwater." The disease appeared in this vineyard in 1885. The J. W. Hart[4] vineyard on the east line of Anaheim was plainly diseased in June, 1886. The place was a Mission vineyard, and was, when struck by the disease, about 20 years old. Besides the Mission vines there were about 50 Isabellas.

I first noticed [Mr. Hart writes[5]:]

> a drying up of the leaves in the month of June, 1886. * * * From observations I should say the disease spread to the eastward. I noticed vineyards lying in the western part of the town looking bad before the blight appeared to a noticeable extent in mine, which lie at the extreme southeast corner of the town. The vines on "G–1" and "H–1" were the last to succumb. The vines on "G–1" and "H–1" first showed the sickness along the ditch of the Water Company, and those on the sandy land were the last to be affected.

The observation respecting the appearance of the disease at a later date upon the eastern side of the town than upon the west and southwest has been substantiated by many of the residents of Anaheim, and was also noted by myself.

Mrs. Strodthoff had a vineyard of 18 acres, mostly Mission, on the north line of the plat of Anaheim.[6] The disease was first seen in the

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[1] See plat of Anaheim, lot "H–6."
[2] Lot "G–6."
[3] See plat of Anaheim, lot "E–3."
[4] See plat, lots "G–1" and "H–1."
[5] Letter of February, 1890.
[6] Lot "A–5."

summer of 1886. It is altogether probable, however, that these vines were diseased, like those of neighboring vineyards, at an earlier date, but it is interesting to note that the record from this northern vineyard, like those from the vineyards of Mr. Hart, on the southeastern boundary, assign a later date to the appearance of the disease than at nearly all the vineyards in the southwest of the town. The vines were removed in the fall of 1887.

The vineyard of J. J. Dyer, of Anaheim, was composed of Berger, Muscat, and Zinfandel vines, 20 acres in all. The Berger vines died first, fully 30 per cent dying in 1886. The fact that these Berger vines died in 1886 is additional proof that the affection was in that portion of Anaheim in 1885, for the Berger succumbs later than the old Mission. Mr. H. Werder, one of the oldest settlers of the region of Anaheim, having resided there since 1859, said he had never known any such disease as the present one among either wild or cultivated vines. The death of the vines on his place was uniform with those about it. There was an output of 3,000 to 4,000 gallons of wine here in 1886, and but 1,000 gallons in 1887, *i. e.*, from the old Mission vines.[1]

EXTENSION OR GENERAL DEVELOPMENT OF THE DISEASE.

From Anaheim as a center the disease seems to have spread rapidly in many directions. The following notes on its occurrence in various localities have been compiled from facts gathered in the field during several months' labor:

Mr. C. J. Hough, of Garden Grove, saw dead vines in 1885, and he thinks a few showed disease in 1884.[2] George Minter, of Santa Ana, said he saw the first signs of disease in the old Mission vines in 1884. Dr. A. L. Cole, also of Santa Ana, claims the disease was manifest in his vineyard in 1884. Mr. F. Rohrs, of the same place, had a vineyard northeast of town. In this were Concord, Catawba, Delaware, Ives, Isabella, and Mission vines. A few Missions failed to come out in the spring of 1885. These he sawed off below the ground and grafted with Bergers. The grafts caught and made a light growth, but died in the heat of summer, showing early that they would not do well. In the spring of 1886 these Missions were again sawed off and again grafted with Bergers. These grafts failed entirely to catch. In the same spring he noticed that many more Mission vines failed to come out, and in the heat of 1886 they nearly all "went back." In general the old Mission vines died in this vicinity in 1886 as at Anaheim, but as there were fewer of these vines near Santa Ana less attention was attracted by their death.

Mr. James Lynn, of McPherson, had a Muscat vineyard of 10 acres removed. They were seven years old when taken out. He believes a few vines were diseased in 1884, and is sure 3 to 4 per cent were diseased in 1885.

[1] Lot "H-7."

[2] See remarks under "Incubation of Disease."

There are but few records of the appearance of disease in the Santa Ana Valley in 1884 outside of Anaheim. The records relating to the Mission vines are most reliable; at least are more likely to relate to the early development of the trouble, for the death of the Muscat vineyards here did not occur before the year 1887. In a vineyard of Bergers set by Mr. A. Reuter in 1881 or 1882 northeast of Santa Ana, the disease was first noticed in 1885. A few vines died in 1886, while in 1887 they produced the characteristic short growth. The crop fell off from 9 tons per acre in 1886 to 2 tons per acre in 1887. Mr. C. Z. Culver, of Orange, had 10 acres northwest of the village of McPherson. He first saw disease in his vines in September, 1885. Dr. J. D. Chaffee, of Garden Grove, had a vineyard of Muscat vines which bore a heavy crop in 1884. He claims that the first appearance of the disease was in 1885.

On the place of Mr. H. H. Roper, southwest of Santa Ana, the Muscats presented the characteristic yellow stripes of the disease as early as the fall of 1885. This was an old and very productive vineyard.[1] Catawba vines grown on an arbor at this place showed disease as early or earlier than the European varieties. In 1885 Mr. Fred Gerken was engaged in the vineyard of Mr. Peter Jones, about 1 mile northwest of Orange, and he observed here many shrunken grapes. They thought at the time there had been a lack of water. Some of these vines died in 1886, the year previous to the more or less general death of Muscat vines on the south side of the Santa Ana River.

Mr. Robert M. Hazard, Tustin City, reports that in 10 acres of Muscat vines on the gravel land southwest of the Hewes ranch near McPherson, the disease was apparent in 1885. This was probably the first sign of disease on the Muscat vines in that region, for the yield of the vineyard was nearly three times as great in 1886 as in 1885. The real loss owing to disease was first evident in this vineyard in 1887, when the output dropped from 1,360 to 350 boxes of raisins. Mr. H. K. Snow, of Tustin, had 100 acres of Muscat vines between there and McPherson. He saw the first signs of the disease in 1885. All but 5 acres was on what is locally known as "the gravel land." At McPherson Mr. F. J. Kimball had a vineyard, mostly of Muscats. In the spring of 1886 he noticed that some of the vines did not come out. He had a good crop, however, in that year, the loss being more in quality than in quantity of fruit.

Mr. A. D. Baker, of Garden Grove, places the appearance of disease among the vines at that place in 1886. Dr. J. Warner, also of Garden Grove, had a Muscat vineyard, some of the vines having been set out about 1877. It bore a heavy crop in 1885; 70 per cent of a crop in 1886; and only 200 pounds in 1887. The vines were removed in 1888. The soil on which this vineyard stood was a rich, deep, sandy sediment. Mr. Warner says the older Muscats died first.

The vineyard of W. G. McPherson, near McPherson, showed the first

[1] For additional facts relative to this vineyard see under head of "Soil poverty."

signs of disease in the summer of 1886. The leaves became spotted and dropped too early. The yield of 1886 was 2,000 boxes of raisins, and this fell off to 900 boxes in 1887, and to 65 boxes in 1888. In a Muscat vineyard 2 or 3 miles south of McPherson the disease was first noted in 1886; and another of the same variety some 3 miles north of McPherson was also diseased in 1886. Peter Ainsworth, of McPherson, had 3 acres of Muscats thirteen years old. He saw the first signs of disease in the springs of 1886 on "stony, leachy ground." His crop was full that year, however, and a good crop was obtained in 1887, but in the fall of that year 75 per cent of his vines were diseased. In 1888 the crop was a failure and the vines were removed the following winter. McPherson Brothers set a Muscat vineyard in 1873. This bore a heavy crop in 1886, a light crop in 1887, and none in 1888. This was the pioneer Muscat vineyard in the Santa Ana Valley and many of the vines were 6 inches in diameter and had always produced abundantly up to the appearance of the disease.

In the vineyard of Muscats belonging to Mr. Fred Gerken, northwest of Orange, the disease appeared in 1886. One vine was so badly diseased that it was cut off in the fall. This vineyard has withstood the disease very well, owing to the nature of the soil and the situation. The soil is rich and sandy, and is one from which the plant can easily secure nourishment and into which its new roots can be easily extended.

In the vineyard of Mr. M. Nisson, a short distance north of Santa Ana, the Black Malvoisie vines showed the first signs of disease in 1886. In 1887 the disease was well marked. Mr. George W. Ford, of Santa Ana, had an arbor covered with Isabella vines. These were set in 1879 from cuttings brought from Redwood, Cal. Disease first appeared here in 1886. The crop of grapes for that year was fair; 25 per cent of a crop was gathered in 1887, and none in 1888. D. B. Thompson, of Tustin, says the Missions died there in 1886.

Mr. Bartlett had a ranch southeast of McPherson. On this was a vineyard of 85 acres of Muscats set in 1881. This showed the first signs of disease in 1886, but produced raisins to the value of $100 per acre in 1887. The output was reduced to $15 per acre in 1888.

At Yorba Mr. Jacob Berlin had 14 acres of vines, a few of which showed the disease in 1886. Those most affected were the Mission. At Norwalk Mr. D. D. Johnston had 40 acres of vines—25 acres of Muscats and the remainder Zinfandels and Bergers. He says the disease appeared in this vicinity in all the vineyards about the same time and in the heat of the summer of 1886. A striking illustration of the hardiness of certain varieties of vine and of the stage of incubation of the disease in the grape is illustrated in this vineyard.[1]

The vines seem first to have been affected about Pomona in 1886. The trouble has not developed as rapidly here as in many other places. This is presumably due to the sandy nature of the soil. It is possible

[1] See under the head of "Incubation of disease."

that the vines did not become diseased until 1887. Mr. J. G. White, who had charge of the 2,300 acres of the Nadeau vineyard at Florence, says that he saw the disease there first in 1886, but no marked reduction in yield was noticed until the season of 1889.

In a vineyard composed of Mission, Black Hamburg, Muscat, Flaming Tokay, and Almeria vines, and located at Westminster, on moist soil, the disease was first noticed by Mr. W. G. McPherson in 1887. At Capistrano Mr. M. Mendelson first noticed the striped appearance of foliage on his Klaeber vines in the fall of 1887. Some vines were taken out in the winter of 1888–'89. Oscar Wells, also of that place, saw the first signs of the disease on the Mission vines there in 1887. His vines were removed in 1888. H. R. Rosenbaum saw the disease first in 1887. More than half of his Mission vines are now dead, and the remainder are rapidly dying.

Mr. J. E. Packard, of Pomona, noticed a diseased appearance of certain parts of his vineyard as early as 1887. The vineyard fell off in yield in 1889 as much as 100 tons of grapes, yet this vineyard is young and should be constantly increasing in yield.

G. B. Simpson, of Florence, says he knew the disease to be there in 1887. Near Los Angeles Mr. F. Roueau says he noticed the first signs of the disease in the Mission variety in the spring of 1887. In that year the output was 895 tons and that of 1888 was 456 tons, a reduction of nearly 50 per cent. Thus the Mission vine was some years later in dying at Los Angeles than at Anaheim. At Englewood we may safely set the date of first appearance or development of the disease as 1887. The vines here were strongly and very characteristically marked in 1889.

At San Bernardino my own observations indicate that some of the vines had been affected since 1887. The disease was developing very slowly in this region, however, and mostly upon the older Mission vines. A few vines were found entirely dead in 1889. At Tropico the disease was plainly present in 1889, and the first development of disease here was probably in 1887. At San Fernando Mr. C. R. Rinaldi noticed the first appearance of disease among his vines in 1887. Many vines, some of large size, were dead in September, 1889.

The death of nearly isolated vines is recorded from Santiago Cañon by Mr. S. Shrewsberry. This gentleman lives in the Santa Ana Mountains many miles up the Santiago Cañon. He had three Chasselas vines on an arbor that bore abundantly for years. One was grafted on the Isabella variety 3 inches below the surface of the ground. These vines were 14 miles from the nearest vineyard. The Chasselas died in 1887; the Isabella grafted on the Chasselas stock was dying in August, 1889. The other Isabellas are perfectly healthy. Mr. A. M. Aldrich, of Riverside, has about 3 acres of Muscat vines. They showed disease in 1888 and probably in 1887. Some Missions were found nearly dead on the place of Mr. Allet, somewhat west of the center of the town, and

others were rapidly dying. The present state of the disease seems to point to its first development here in 1887. Mr. J. G. Pierce, of Riverside, states that he saw dead Muscat vines at that point in 1888, and others not maturing their fruit in 1889.

On J. C. Joplin's ranch, in Bell Cañon, Santa Ana Range, about 26 miles from Santa Ana toward the southeast, is a collection of 40 or 50 vines grown on a trellis. These vines are of several varieties and did not show the disease until the spring of 1888. The Missions failed to bear and the other varieties, with one exception, bore but half a crop, the exception being in favor of an eastern variety. At Santa Barbara, on the place of George Faber and others, the vines had many characteristics of disease. Owing, however, to the effects of mountain fires and to *Oidium*, which was very severe here, any judgment as to the actual death of the vines from the disease must be deferred. If their condition was due to the malady under consideration, then its first development may be set at about the season of 1887; certainly not later than 1888.

N. B. Hicks, of San Bernardino, had 2¾ acres of old Mission vines on his place near the city. He first saw the disease in 1887, and so many of the vines died in 1889 that he removed them in 1890.

The old Mission vineyard of Prof. C. R. Paine, east of Redlands, was examined in 1889. From the stage reached by the disease here it is evident the vines were affected in 1888. They are not failing as rapidly as those nearer the point of first appearance of the malady. This vineyard was planted in 1858, making it at the present time older than the oldest of the vineyards at Anaheim at the time of their death in 1886. There was a marked decrease in the crop in 1890, and it is not unlikely that much of the crop will dry upon the vines in 1891. [They have since been removed.—May, 1892.]

Evidence that vines were diseased at San Jacinto in 1888 was found in August, 1889, on the vines of L. C. Letner and L. Morehouse. There were vines in the vineyard of the former which had made a short growth, not more than a foot for the entire season, although the vines from their size indicated previous growth and health. Some of the vines were nearly dead. At Glendale is a vineyard belonging to J. E. Fisk. These vines first showed the disease in 1888, the Malagas, however, not until 1889. At Encinitas the vineyard of E. P. Tallant showed disease plainly in 1889 and the wood of the vines was unusually dry when pruned in November, 1888. This is a well-known characteristic of the disease in the region where vines have been worst affected. A considerable number of vineyards were examined in this neighborhood and none were found in a perfectly healthy condition. Some of the older vines showed an advanced stage of disease. In the vineyard of Peter Bonet, at Corrento, vines showed disease in 1888 and the affected stocks were cut out in January and February, 1889. Maj. Chase, of the Cajon Valley, San Diego County, states that the first appearance of the

disease among his vines was in the summer of 1889. As far south as Otay there are marked signs of the weakening of vines. This is especially true in the older vineyards. Mr. George D. Woolsey, of that place, says that about 100 vines were stricken by some kind of blight in 1888.

> I trimmed them in March very closely and there were only two or three of the diseased vines that ever started again. Those that have started send out a little sickly shoot and die down again. The disease has spread but very little this season (1889); it is mostly on those that were affected last year. * * * The disease first appeared on the Muscats, then on the Flaming Tokay.[1]

There are some exceptions to the development of disease in vines at later dates as we pass further from Anaheim. Age, hardiness of variety, favorable situation, or unknown causes have in numerous cases acted to preserve certain vineyards or portions of them far beyond the time which would be assigned for their death by judging from the death of surrounding vineyards. A few examples are here given. As the entire region affected becomes more nearly denuded these cases will seemingly be more numerous and certainly be more marked.

A vineyard of Bergers and Malvoisies at Fullertown, belonging to Mrs. Strodhoff, showed the first signs of disease in 1887. Mr. S. G. Baker reports that in his vineyards at Norwalk the disease first made its appearance in the summer of 1888; on some varieties not until 1889. I have myself noticed that vines at Norwalk were not so early affected as at other near points. Much of the region is artesian and many of the vineyards are upon loose sandy soil. These two facts may account for the seeming irregularity. The death of vines here corresponds somewhat closely with that of those about Westminster, which are also upon artesian ground. Some of the vineyards near Norwalk, which are doing comparatively well, are of young and hardy stock. This might account for their present condition. In fact some of them have been set since the appearance of the disease at Anaheim. Near Orange the vineyards of John Roth, F. Gerken, and Mr. Hager were doing so well after the death of the adjoining vineyards that their owners felt confident they would be touched only lightly, if at all, by the disease. On the place of John Roth the Muscats bore a fair crop in 1888, and he stated that the disease first showed in his young vines in that year. It had been all about him, but the loose and rich sedimentary soil and recent setting of these vines had preserved them beyond the date when other vineyards became unprolific. This is also true of much of the Hager vineyard. In Mr. Gerken's vineyard, close to the others, although the disease appeared in 1886, the Muscats and Bergers continued to bear until 1889. In that year he made a considerable quantity of raisins, although the yield was not so heavy nor the output as valuable as it would have been without the presence of the disease. The Bergers bore their fruit up to the vintage, but just as it became fit for picking

[1] Letter dated Otay, July 3, 1889.

the leaves fell and the grapes dried and were worthless. Plate III, showing a Berger vine loaded with dried grapes, was from a photograph of a vine in this vineyard. A similar instance with the Berger vine occurred at Norwalk, in the vineyard of D. D. Johnston. In June, 1889, the vines here were without any apparent disease, and were full of grapes. Everything looked as if the vines were perfectly healthy, but they failed just before the vintage, as I was informed by Mr. Johnston on November 23, 1889.

There is still another case of exceptional vitality in the face of the disease which is worthy of mention. On the place of Mr. Langenberger, at Anaheim,[1] is a tract of Lenoir (Jacques) vines which were nearly all alive in 1889. This is not a case of apparent exemption from disease, but of great vitality on the part of the stock, as the disease has been more or less apparent here for some time.

THE DEATH OF THE VINEYARD AS A WHOLE.

The time of death of any given vineyard affected by the disease under consideration is a matter not easily determined. There are many and varied conditions which may influence the ultimate result. But the death of a vineyard once badly diseased is only a question of time. The time generally required to kill the majority of vines in a vineyard is from two to five years, according to variety, age, soil, temperature, humidity, care, protection from sun, etc. The effect of these numerous conditions bearing on the action of the disease will be considered more in detail in subsequent chapters. In some cases certain vines live for five years, or even more; in other cases they appear to die in one season. In some cases entire vineyards will seemingly succumb in a single season, although as shown in the notes on incubation of disease it is probable these vines had felt the influence of the disease some time previous to its apparent development and the death of the stocks. A few examples of this rapid death are worthy of a detailed account as their history is that of hundreds of vineyards now dead.

Mr. Lovering, of Anaheim, had a Zinfandel vineyard of 10 acres, which, to all appearances, would yield 50 tons of grapes. The disease appeared suddenly in the heat of the season and he obtained only 9 tons of fruit from the whole 10 acres.

Mr. J. F. Bennett, 2¼ miles north of Orange, had a vineyard on rather sandy soil, where it held out unusually well. On June 16, 1888, his Muscats were in a prosperous condition so far as external appearances were concerned. His neighbor remarked that he would not sell his crop on 10 acres similar to these for less than $1,000. These vines were irrigated between June 16 and June 20, and were cultivated. Within a week the leaves looked as if a fire had passed over them. The edges were curled and the surface had a dry, harsh appearance, the normal bright green color having disappeared. The canes showed disease at

[1] See plat of Anaheim, lot "B-5."

the ends. Summer pruning was not practiced this season, and some of the canes had a growth of 15 feet. Some of the vines would have matured 50 pounds of fruit if the disease had not affected them. By July 4 the vineyard, as a whole, began to "go back;" the fruit dried on the vines, and as Mr. Bennett stated it, within a year the vines could be kicked over.

Mr. D. D. Johnston had 40 acres of vines of Muscat, Zinfandel, and Berger varieties, three-fourths of a mile southeast of Norwalk. The Muscats showed most disease, the Zinfandel less. The Bergers were apparently not affected, that is, no external evidences of disease were manifest. All these vines were on sandy, moist, artesian ground. A letter from Mr. Johnston, dated November 23, 1889, shows the effect of the warm weather upon the vineyard. "In June, when you were at my place, there was not one affected vine in my Berger vineyard. As the season advanced I began to notice signs of disease, and finally, before picking grapes, there was one-third affected, some vines so much so that the grapes at various stages stopped growing as if the vine had been girdled. On some vines the grapes nearly ripened and at once stopped and did not sugar; other vines less affected matured their grapes. My Zinfandels acted about the same. The Muscat has suffered most."

Vineyards near the center of the affected district, before the removal of the majority of the vines in that region, died more rapidly and more uniformly that did those at more distant points. On the other hand, there are indications that the central region of disease will be the first point within the limits of the badly affected district where vineyards may be reset with safety.

The sporadic death of vines or appearance of disease in a vineyard is the more common one, although more marked with some varieties than with others. In some of the varieties whose leaves turn yellow or red through the action of the disease, its distribution is apparently more sporadic than in those vines whose leaves remain green until the death of the vine. This may result from the fact that in one case the degree of disease present is shown, while in the other we are deceived by a healthy external appearance. There is a degree of truth in this healthful appearance, however, for a good growth of cane and abundant fruit are often found on the vines showing green foliage, while in the varieties having spotted foliage sporadic stunting of the top and deficiency of fruit is more common.

The foliage of the Muscat vine is strongly marked by disease. In vineyards of this variety it is common to find the malady showing a sporadic distribution. Among thrifty vines there may be one with spotted leaves and stunted growth, and in an advanced stage of disease. In the younger and more favorably situated Muscat vineyards the slower, sporadic progress of disease is likely to be more marked than among older stocks or vineyards or those in less favorable situations. The reason is that anything tending to the weakening of a vineyard,

as age or unfavorable location, will induce a rapid and more general death of the vines. The sporadic progress of disease is, however, common and well marked, but of shorter duration in old vineyards. As far as characters of foliage are able to show the disease gradually develops in Muscat vineyards in an irregular manner, till a majority of the stocks are involved. This development of disease has seemingly no regularity even among vines under like conditions—the only key to the order of its development being a supposed individual weakness or susceptibility. In a late stage of disease, especially well marked in the Muscat vineyard, the sporadic appearance is reversed, and we find here and there a vine retaining its healthy appearance, growth, and fruitfulness, nearly as conspicuous in a diseased and stunted vineyard as a standing oak in a windfall. There seems no explanation of this except individual resistance to disease. At last, however, these hardy stocks give out and the destruction is complete.

An *increase of fruitfulness*, although occurring with variable constancy, is claimed to be among the first signs of a diseased state of a vineyard. It is universally observed that the irritation caused by the direct or indirect action of parasites or pathogenic organisms, be they of animal or vegetable nature, will cause a stimulated and abnormal action of the circulation of their hosts. This is well marked in nearly all germ diseases in the animal kingdom, prominent among which are the germ fevers. Vegetable enlargements or monstrosities due to the irritation or stimulative action of some localized parasitic fungus are of even more common occurrence. Millardet clearly records the fact that vines first attacked by the root fungus *Agaricus melleus*, observed by him in the south of France, produced a very heavy yield of grapes before any other signs of a diseased condition became apparent. This is strikingly illustrated in one case to which he refers. At the margin of a group of vines attacked by this fungus were some to all external appearances in a perfectly healthy condition. These vines were producing an unusually heavy yield of grapes. Outside of this line of vines the yield was normal, and inside of the line the growth of the tops clearly showed the action of the fungus. The heavily producing vines did not show external signs of disease until the following season, when they presented the appearance of those vines located near the center of the circle the preceding season.

In a vineyard where all vines are presumably attacked alike by disease, it is difficult to say with certainty whether a given yield be normal or abnormal. If the affected stocks were known to be confined to a certain portion of a vineyard or to a certain vineyard in an unaffected vine-growing district, comparison would show what was a natural and what an abnormal fruitfulness. But where every vine in an extensive vine-growing region is affected, and no well-marked limits to the disease can be assigned, and when to this is added the fact that local conditions affecting the vines are variable, and that many vineyards

are young and naturally increasing in production, it becomes apparent that doubts are justifiable without abundant observation.

Owing to the different amount of resistance offered to this disease by the numerous varieties of vine, the year when one variety feels the effect of disease sufficiently to cause unusual fruitfulness may be a year when a less hardy stock, perhaps in an adjoining vineyard, may almost wholly succumb. It is not improbable, either, that of two vineyards of one variety, one young and the other old, the latter would first produce its abnormal crop, other things being equal. This would simply mean that the weakest stock is the first to show the influence of the disease.

The effects of the disease on different varieties in regard to fruitfulness is brought out by the following quotations: The Anaheim Gazette of October 10, 1885, says:

> Many paragraphs have been printed this season regarding heavy yields of grapes, but we are gratified to be able to cap the climax by recording the phenomenal yield of the Muscat vineyard of Mr. John J. Duff, situated about 1 mile north of town. The vineyard yielded 12 tons to the acre, and there is about a ton of grapes to the acre, second crop, left on the vines. Two vines gave three trays of grapes, each weighing 70 pounds, making the yield for each vine 105 pounds. Mr. Staley, foreman for McPherson Brothers, who purchased the crop, says that this is the heaviest yield of any vineyard in the county. * * * Mr. Duff will realize $200 per acre (including second crop) with no expense of picking, curing, etc.

As it is now known that the Muscat vine will resist the disease at least one year longer than the Mission, in some cases two or three years, it is usually much later in showing the effects of the disease in its yield. The old Mission vines were producing only a light crop this year.

The following year we find a still more striking and interesting contrast recorded in the Gazette. On September 11, 1886, that journal says:

> The crop in some of the pioneer [Mission] vineyards will be so small that the owners have sold a part of their winery utensils, such as tanks, puncheons, and barrels.

Two weeks later the same journal remarks:

> The vineyards of Anaheim and vicinity, with the exception of those bearing Mission grapes, are yielding much more than an average crop this year. The Zinfandel and Malvoisie varieties are "panning out" especially well, many vineyards yielding from 5 to 8 tons to the acre.

It has since been shown that the Malvoisie vines are among the most hardy. All the vines referred to in the quotation are now dead.

Besides comparing vines of different degrees of resistance by means of their product for a single season, it will be, perhaps, more illustrative to record the yield of single varieties and vineyards for several years, at the advent of disease, and at different points in the affected district.

The place of Dr. J. D. Chaffee, of Garden Grove, included four-fifths of an acre of Muscat vines, planted in 1877. The vines produced an abnormal crop in 1884 when they were first struck by the disease. They commenced dying in 1885, and were removed in 1888. The yield of this vineyard is given in pounds of raisins. In 1880, 500 pounds; 1881, 900

pounds; 1882, 3,000 pounds; 1883, 3,000 pounds; 1884, 4,000 pounds; 1885, 3,000 pounds; 1886, 2,500 pounds; 1887, 1,000 pounds; 1888, nothing worth saving. Here the yield for 1884 was 33 per cent greater than that for 1882 or 1883, and from this time the crop steadily decreased until the death of the vines. These figures are in round numbers and are partially drawn from memory.

Mr. S. G. Baker, of Norwalk, had a vineyard containing the following varieties: Mission, 35 acres; Berger, 2 acres; Zinfandel and Muscat, 3 acres. The vines were planted at various times between 1860 and 1870. Ten acres died in 1887 and 30 acres in 1888. They were removed in 1890. The yield in this vineyard is given in pounds of fruit per acre. In 1880, 4,000 pounds; 1881, 8,000 pounds; 1882, 10,000 pounds; 1883, 10,000 pounds; 1884, 20,000 pounds; 1885, 14,000 pounds; 1886, 6,000 pounds; 1887, death of some of the vines; 1888, continued death of vines; 1889, vineyard worthless; 1890, but 3,000 vines of any degree of health left out of the 40 acres. These figures show that the year 1884 was a wonderfully productive one, the vines yielding at least 10 tons of grapes per acre, while in former years they had never risen above 5 tons per acre. The year 1885 also gave a large yield, and from that time the vines died rapidly. In the fall of 1890 but twelve Mission vines were growing in the 35 acres. This case is of special value from the fact that the vines were old and in full bearing years before the appearance of the disease.

Mr. T. H. Brigham kindly furnished records of two varieties of vines grown near Florence. The first vineyard contained 8 acres of Muscats, planted about the spring of 1877. About 1,000 vines died in 1889 and 1890, and half or more of the vines were distinctly diseased. The yield is as follows in tons of fruit from the 8 acres:

	Tons.
1882	35
1883	45
1884	57
1885	74½
1886	71½
1887	64
1888	[1]106
1889	30¼
1890	[2]35⅞

Two facts are prominent in this record: (1) The disease affected the vines much later than at Garden Grove and Norwalk; (2) the overproduction was very marked, and followed three years in which the output was nearly uniform but slightly on the decline.

That this vineyard had reached full productiveness before the appear-

[1] Fifteen of these rotted on the vines.

[2] The record shows a slight gain in 1890 over 1889. As Mr. Brigham had in part a young vineyard, it may be that this increase is due to its coming into bearing, but of this I am not informed. Mr. Brigham's vineyard has since become worthless and is to be removed.

ance of the disease is evident both from the age of most of the vines (ten or eleven years) and the uniformity of yield from 1885 to 1887. Both the great increase in yield and the remarkable drop in one year to less than one-third may justly be attributed to the effects of the disease. It is especially interesting to note that this overproduction did not occur immediately following the excessive rainfall of 1883–'84, as at Garden Grove and Norwalk, and it is therefore evident that the rainfall had no direct bearing on the abnormal yield. It is also in perfect accordance with the later devolopment of the disease and death of vines at Florence and Los Angeles than at Anaheim, which is much nearer Garden Grove and Norwalk.

Mr. Brigham's second vineyard comprised $2\frac{2}{3}$ acres of Mission vines planted as rooted cuttings in the spring of 1883. These vines did not show much disease in 1888, but were mostly dead or worthless by the close of 1889, and were removed in the spring of 1890. The yield, given in tons for the whole vineyard, is as follows:

	Tons.
1886	7
1887	$16\frac{2}{3}$
1888[1] (about)	28
1889	6

The record is of less value than the preceding, as the vines were younger, but the facts are substantially the same. As these vines were only 4 years old in 1886, it may be held that a part of the increased crop in 1887 was due to the maturing of the stocks, but it can not be justly held that all this increase in 1887, and again nearly double the amount in 1888, was natural increase when the vines were so badly diseased that they were mostly dead the following year. The great increase of 1888 was evidently due to the stimulative action of the disease, and possibly a part of the yield for 1887 should also be thus accounted for.

Adjoining the place of Mr. Brigham on the east is a vineyard of 25 acres of Muscat vines belonging to Mr. A. W. Thaxter. These vines were set in the spring of 1883 as rooted cuttings. They died in 1889 and 1890, and were removed in December, 1890. The yield is given approximately in tons for the vineyard from 1885 to 1890.

	Tons.
1885	60
1886	120
1887	158
1888[2]	235
1889	150
1890	50

It may be that the rotting of the grapes on the vines of both Mr. Thaxter and Mr. Brigham in the season of 1888 was in part due to the

[1] In the year 1888 some 12 to 15 tons were not gathered, as they rotted on the vines.

[2] About 75 tons were never gathered in 1888, owing to their rotted condition.

disease. It was quite largely observed at Anaheim in the death of the old Mission vineyards.

In the Nadeau vineyard at Florence the yield in 1888 was the larger one for the time. In 1889 it was reduced 25 per cent in spite of the fact that many of the vines were quite young. About Santa Ana the years of overproduction were 1885 and 1886, mainly the latter. This again shows that no direct connection exists between the rainfall of 1883–'84 and the matter of overproduction. It also accords well with the date of the death of vines in that region and the distance from the place where disease first developed.

The yield of the Muscat vineyard of R. M. Hazard, set in 1882, near Tustin, in boxes of raisins on 10 acres is as follows:

	Boxes.
1885	474
1886	1,360
1887	350
1888	170

A portion of the crop of 1886 may have been due to natural increase in productiveness but it can hardly be claimed that all of it was natural, especially when the following year's crop was little more than one-fourth this amount.

Mr. A. Reuter, near Santa Ana, had two vineyards, one of Muscats set in 1878 and one of Bergers set in 1881 or 1882. The record from the Muscat vines is of the most value as they had been in full bearing for some years prior to the appearance of the disease. The yield is given in tons per acre.

	Tons.
1881	4
1882	7
1883	7
1884	7
1885	8
1886	8
1887	3
1888	1

The Berger vines bore per acre:

	Tons.
1884	8
1885	9
1886	9
1887	2
1888	0

In both these cases the vines bore an increased amount of fruit for two seasons prior to their rapid death,[1] and the record agrees with the others given relative to the development of the disease in this locality.

Near Redlands is a Mission vineyard planted in 1857 and belonging

[1] It is probable that a part of Mr. Reuter's grapes rotted on the vines in 1886, and of these no account is taken.

to Prof. C. R. Paine. Beginning in 1886 the yield in tons per acre is as follows:

	Tons.
1886	5.52
1887	8.14
1888, including those rotting on the vines	7.46
1889	4.14

Here is a decided increase in production in these old vines which had long since reached full maturity. It is of interest to note that the large crop did not come in 1884 as at Garden Grove and Norwalk, nor in 1885 and 1886, as at Santa Ana and Tustin, but in 1887 and 1888, agreeing with the distance from the center of the infected region.

Although the matter of overproduction due to the action of the disease has not been worked up as thoroughly as might be desired, and although there may be some doubt still remaining, the evidence certainly favors the idea that overproduction is induced by the disease. I believe that future work will bring to light facts which will indorse rather than refute the evidence presented.

Decrease in fruitfulness in the diseased vineyards near Anaheim and throughout the district first affected progressed more rapidly than it is progressing at present further from the center of the diseased area. This loss in yield is slow or rapid according to the progress of the disease in the individual stocks. In many old vineyards, in some unfavorably located for obtaining moisture and nourishment from the soil, and in certain varieties not so conditioned, a good crop one year may be followed by an almost complete loss of fruit the next. This was the case with some of the old Mission vineyards of Anaheim. In a large majority of the dying vineyards, however, the loss is more gradual, but increases from year to year as the stocks become more weakened.

DEATH OF THE INDIVIDUAL VINE.

Like the death of the vineyard as a whole, the death of the individual vine varies according to its variety, age, situation, etc. Some varieties present more clearly discernible characters of disease than others, but there is an order followed quite generally in the death of all vines, of whatever variety.

In most vines not showing external signs of disease, the first visible effects are noticed in the foliage. This change is not usually visible in the early spring. During the early months of the year the growth may be normal and the fruit set fairly well. The diseased appearance begins to show as the heat of the season comes on, usually in June. As the season advances the markings of the leaf becomes more distinct and more general.

The foliage marking is followed by a more general and much more important character, the premature fall of the leaves. The discoloration and dying of the leaves prior to their fall, have special characters

in each variety and each needs a special description. The premature falling of the leaves will apply to nearly or quite all varieties, though taken alone it is not distinctive of the disease.

Dependent upon the premature fall of the leaves is the unripened state of the cane. The leaves not only fall before the proper time, but before having accomplished the ripening of the canes. As a consequence nearly all the unripened portions of the cane usually die, often shortly after the fall of the leaves, and nearly always before the next spring. Owing to the fact that the growing point is the last to mature its wood, it is first to die after the fall of the leaves. This accounts for what is locally known as *dying back from the top*. It is also one of the several reasons assigned for the belief that the disease is seated or takes its origin in the upper part of the vine.

New characters are developed after the first season. In the spring of the second or third year, the new growth, which starts out somewhat later than usual, though at first appearing normal, soon shows the enfeebled condition of the plant. As warm weather comes on the canes often cease growing or grow slowly, frequently not more than 2 feet during the entire season. A striking feature of this stage of the disease is sometimes presented in an inequality of growth on different parts of the same vine. It is not uncommon to see one side of a vine normally developed, while the other presents stunted canes and strongly mottled leaves. There is no apparent uniformity in this inequality of growth, but it seems based on individual conditions. In succeeding seasons the contrast may be even more marked in individual cases. One side or portion of a vine may be dead and dry, other portions still presenting a moderate though diseased growth. Although these erratic conditions exist, a uniformly diseased state of the vine top is more common. From season to season, as long as the vine retains life, the growth made during the early spring becomes less and less. The warmth of the season at last conquers the vine, and the entire top, spurs and all, dies back to the trunk. Again, death may occur in the winter, and the vine fail to start in the spring; or it may begin to grow, producing canes but a few inches in length, and then die somewhat suddenly. The time taken to produce this result is variable, and modified by many external conditions.

It is well known that the grapevine is not easily killed. This is strongly shown in the effort which these vines make to retain life and reproduce a healthy top. As the old vine dies there are often sent out from its trunk or roots, at or beneath the surface of the ground, new shoots, which make a good growth and at first present leaves of healthy appearance. This secondary growth may keep up the life of the vine and carry it over for another season, but it finally dies in the same manner as the parent stock. These healthy shoots, coming from the roots or well down upon the trunk of the vine, after the top is nearly or quite dead, have given a second reason for the assumption that the

disease originates in the upper portion of the vine. These secondary growths usually depend upon the hardiness of the stock and upon the age of the vine; in other words, the vine dying most slowly is often, though not always, most liable to produce ground shoots from dormant buds. This is to be expected, although much depends on the habit of variety.

An examination of the root system at an early stage of the disease is unsatisfactory and confusing. The main roots are seemingly healthy, even the growing points are quite generally in a normal condition, and no characters are prominent enough to demand consideration under this general head.

As the disease makes further headway upon the upper parts of the vine the smaller root fibers are found to be shrunken. This is more evident on some roots than on others. Decay soon takes place, the rotting following the finer fibers back to the larger until the entire root system is involved. As in the case of the ground shoots from the top of the vine, secondary roots are often formed above the original system close to the surface of the ground, or they may be midway of the trunk below the surface. These, like the "suckers," are among the last to die back. In many cases nearly the entire system of roots is rotted away before the top finally dies. The last point to succumb is that close to the surface of the ground nearest the secondary roots and ground shoots.

CHAPTER V.

BEARING OF SOIL CONDITIONS ON THE DISEASE.

VINEYARD RECORDS.

Most of the data which have served as a basis for the tabulated record on page 83 have been furnished by the owners of vineyards, and coming from different parts of the affected region show many of the soil and water conditions under which the disease has existed. The following supplementary notes relating to the vineyards considered include details which do not admit of tabulation:

NOTES ON THE RECORDS.

Vineyard No. 1.—Owned by Mr. W. G. McPherson, at McPherson. The pruning in this vineyard had been done when the vines were most dormant, from December 10 to January 15. After the first year it had only been irrigated in the winter. The Sultana vines died before the Muscat. In 1886 the vineyard yielded 2,000 boxes of raisins.

Vineyard No. 2.—Record supplied by Mr. W. G. McPherson. Situated about 2½ miles south of McPherson. It is said to have yielded very fine raisins in its palmy days. The vines were 7 years old and in full bearing when struck by the disease.

Vineyard No. 3.—Belonged to Mr. Snyder, and situated about 3 miles north of McPherson and opposite the mouth of the Santiago Cañon. Mr. W. G. McPherson, who examined this place in 1887, says of it:[1] "My attention was called to this vine disease forcibly in March, 1887. I was then deputy assessor, and was placing a value on vines. I was near Mr. Snyder's place at the mouth of the Santiago Cañon. The neighbors wanted me to go and examine Mr. Snyder's vines, as he had reported them dying. They considered him an alarmist, but wanted me to see them. I did so, and found he had just cause for alarm. There was not a healthy vine in the vineyard. I stopped work and spent three days examining vineyards. * * * There was something wrong to be seen in all of the vineyards."

Vineyard No. 4.—Owned by Mr. W. G. McPherson, and located at Westminster, within the artesian belt. The vines were on moist soil, and received no irrigation. They had always yielded heavily, and had been known to produce a growth 20 feet long in a single season. As seen by the table it is only 8 feet to permanent moisture, where quicksand is reached. The vines were the Mission, Black Hamburg, Muscat, Flaming Tokay, and Almeria, and they died in the order here given.

Vineyard No. 5.—Composed of Mission vines; located at Norwalk, and owned by Mr. S. G. Baker. The disease is said to have appeared in 1888. Although this may have been the season when dying vines were first noticed, it is probable that it had been working there some time previously. It is true, however, that the vineyards of Norwalk are dying at a later date than their geographical location would lead one to expect, and are among the exceptions to the orderly death of vines outwards from Anaheim. The reason seems to be the loose, rich, moist soil, and their lower position. They may be compared with the somewhat similarly situated vines near Orange, in charge of Mr. Hager. In 1889 all the vines were affected, and they bore

[1] Letter of September 23, 1889.

only a few grapes. It contained 35 acres, set at various dates, and they were removed in the winter of 1889–'90. In the summer of 1890 the place was planted in corn, and produced 40 bushels per acre.

Vineyard No. 6.—A Berger vineyard, also belonging to Mr. Baker. the vines died in a more sporadic manner than those of No. 5.

Vineyard No. 7.—At Norwalk and also belonging to Mr. Baker. A few Muscat vines died in the summer of 1889, and the mottled leaves showed them all to be diseased. Mr. Baker noted the first appearance of the disease in 1889, but he probably meant the general and strongly marked appearance, for some of the vines died in 1889.

Vineyard No. 8.—A fourth vineyard belonging to Mr. Baker. Composed of Zinfandel vines, some of which died in 1889. The remarks relative to the appearance of the disease will apply here also. In all these vineyards at Norwalk permanent water is reached at a depth of 12 feet. This entire region, like that about Westminster, is within the artesian belt.

Vineyard No. 9.[1]—An old Mission vineyard at Anaheim belonging to Henry Kroeger. The soil is uniform in nature to a considerable depth, and like the soil in general in that vicinity is loose.

Vineyard No. 10.—Composed of Queen Victoria vines and belonging to Mr. Kroeger, and located at Anaheim.

Vineyard No. 11.—Of the hardy Malvoisie variety. Also belongs to Mr. Kroeger. The vines became unprofitable and were to be removed in the winter of 1890.

Vineyard No. 12.—A young Zinfandel vineyard also belonging to Mr. Kroeger. The vines were not in a bearing condition or were just beginning to bear when the disease first appeared in the older vines in 1884. The vines showed disease in 1885 and died in 1886–'87, having been removed when only 5 years old.

Vineyard No. 13.—Muscat vines set in sandy loam, located at McPherson and belonging to McPherson Brothers. The soil contained some streaks of gravel from 6 inches to several feet in thickness. Under these the soil is as above.

Vineyard No. 14.—Muscat vines, but located on gravel soil. At the same place and owned by McPherson Brothers. The soil becomes less and the gravel more prominent as the depth increases. It is over 100 feet to water here.

Vineyard No. 15.—Located at the southwest in the El Cajon Valley, San Diego County, and the property of Maj. Levi Chase. The vines affected were mostly old, and several varieties were more or less touched by the disease. A white, wine grape was the one most affected, but Muscats and Tokays were also diseased. They were not wholly dead when several were removed in 1889. The leaf markings so distinctive of the disease were observed to be strongly developed in the summer of 1889.

Vineyard No. 16.—Belonging to Dr. A. L. Cole, and located just north of Santa Ana, and containing some old and some young Muscat vines when the disease became apparent. Mr. Cole says the old vines showed the disease in 1884. It is possible there is a mistake in this date, as the Muscats are slower in developing external characters of disease than the Mission, and that variety did not show signs of the disease until 1884. The young vines were set in 1885, but they showed disease in 1886 in uniformity with other vineyards. They died in 1888, and were removed the same year.

Vineyard No. 17.—Belonging to Prof. C. R. Paine, near Redlands. Mission vines 32 years old. They have been well cared for and always produced well. Distinctly yellow in foliage when visited in 1889. The crop has since been failing. Several groups of vines are already dead. The record of the yield here shows the stimulative action of the disease.[2] [They have at last been removed.—May, 1892.]

Vineyard No. 18.—Situated just north of Santa Ana and belonging to Mr. M. Nisson. The vine shown on Plate v was taken from this place. Vines were of Black Malvoisie variety and young. In 1889 all the vines were dying. A Muscat vineyard at the side of these vines was removed in the winter of 1889–'90.

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[1] See plat of Anaheim, lot "F–2."

[2] See under head of "Increase of fruitfulness," Chapter IV, p. 73.

Vineyard. No.	Variety.	Soil. First 2 feet.	Second 2 feet.	Third 2 feet.	Fourth 2 feet.	Fifth 2 feet.	Vines planted.	Disease appeared.	Vines died.	Vines removed.	Care given.	Depth to water.
												Feet.
1	Muscat and Sultana	Gravelly, with mixture of clay; at least 50 feet in depth					[1]1881 [2]1883 [3]1885	[4]1886	[5]1887 [6]1888	[7]1889	Good	100
2	Muscat	Rich alluvial; very deep					1879	1886	1887	1888	Good	30
3	do	Adobe mixed with mountain wash to a depth of 2 feet, a loose friable soil below 2 feet, lying on hard red clay.					1883	1886	1887	1887	Good	50
4	Mission, B. Hamburg, Muscat, F. Tokay, and Almeria.	Sandy loam, running into a quicksand at a depth of about 8 feet.					1874	1887	1888		Good	8
5	Mission	Sandy loam	Sandy loam	Sandy loam	Sand and clay loam.	Clay loam	1860–78	1888 [?]	1888–89	[8]1888	Good	12
6	Berger	do	do	do	Sandy loam	do	1878	1888 [?]	[9]1888		Good	12
7	Muscat	do	do	do	Clay loam	do	1878	1889 [?]	[9]1889		Good	12
8	Zinfandel	do	do	do	do	do	1878	[10]1889 [?]	[9]1889		Good	12
9	Mission	Adobe, loose but heavy.	Adobe, loose but heavy.	Adobe, loose but heavy.	Adobe, loose but heavy.	Adobe, loose but heavy.	1874	1885	1886	1887	Good	40
10	Queen Victoria	Adobe, heavy	Adobe, heavy	Adobe, heavy	Adobe, heavy	Adobe, heavy	1881	1885	1886	1887	Good	40
11	Malvoisie	Adobe, loose	Adobe, loose	Adobe, loose	Adobe, loose	Adobe, loose	1880	1885			Good	40
12	Zinfandel	Gravelly, mixed with adobe.	Gravelly, mixed with adobe.	Gravelly, mixed with adobe.	Gravelly, mixed with adobe.	Gravelly, mixed with adobe.	1883	1885	1886–87	1888	Good	50
13	Muscat	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	1876–88	1887	1887–89	[11]	Good	125
14	do	Gravel soil	Gravel soil	Gravel soil	Gravel soil	Gravel soil	1876–88	1887	1887–89		Good	125
15	Muscat, Tokay, etc	Sandy gravel, largely decomposed granite.	Sandy gravel, largely decomposed granite.	Sandy gravel, largely decomposed granite.	Sandy gravel, largely decomposed granite.	Sandy gravel, largely decomposed granite.	1876	1889		1889	Good	[?]
16	Muscat	Heavy dark loam with a little gravel.	Heavy dark loam with a little gravel.	Heavy dark loam with a little gravel.	Heavy dark loam with a little gravel.	Heavy dark loam with a little gravel.	1885	[12]1886 [13]1884	1888	1888	Good	43
17	Mission	A red soil with gravel; not much alkali.	A red soil with gravel; not much alkali.	Rock below	Rock below	Rock below	1853	1888 [?]	[14]	[15]	Good	[16]
18	Black Malvoisie	A friable dark loam, rich, a slight mixture of fine sand and clay in streaks.	A friable dark loam, rich, a slight mixture of fine sand and clay in streaks.	A friable dark loam, rich, a slight mixture of fine sand and clay in streaks.	A friable dark loam, rich, a slight mixture of fine sand and clay in streaks.	A friable dark loam, rich, a slight mixture of fine sand and clay in streaks.	1881 or 1882	1886	1889	[17]	Good	38

[1] Twenty acres. [2] Ten acres. [3] Two acres. [4] Leaves spotted and dropped too early. [5] Two per cent. [6] Nearly all. [7] February. [8] In part. [9] A few. [10] On a few. [11] Not removed. [12] In young vines. [13] In old vines [?]. [14] Well marked with disease in 1889. [15] Still producing in 1890. [Since removed. May, 1893.] [16] Great depth. [17] Still remaining in 1889.

DRAINAGE.

Elevation and slope.—In general, the surface drainage is perfect throughout the worst affected district. The slope is from the Coast Range or its foothills to the sea. The coast system is here composed of the San Bernardino range and mountains of subordinate importance, such as the San Jacinto, Santa Ana, and Temescal, with their outlying foothills. These elevations, together with the rolling and submountainous region further south in San Diego County, and with the mountains of Ventura and Santa Barbara counties, afford unexcelled facilities for irrigation over the whole of the cultivated portion of southern California, and give most excellent surface drainage for all the southern counties. It should be understood that a large percentage of the Muscat vineyards have been planted on the more elevated lands, close at the base of the foothills, where the soil is warm and early, produces a sweet berry, and where the greatest advantages are enjoyed during the curing season. Numerous vineyards have also been set on steep hill slopes, which afford immediate drainage to all superfluous water. Hundreds of acres of vines have entirely disappeared from the slopes skirting the foothills northeast of Tustin, at McPherson, and El Modena; and many cases are known where vineyards have died in elevated situations before they had done so on the low and level tracts near the river bottoms.

Loose soil.—The soils of southern California are as varied as the locations of the ranches, but large extents of the most productive vineyards are grown on soils which are, to a considerable depth, of a loose, sandy nature. There are, however, notable exceptions to this. The soils about Anaheim resemble those of southern France bordering the Mediterranean. This fact has been noted by Prof. Viala as indicating the nonexistence of Phylloxera as a cause of the malady. About Norwalk there is much sandy vineyard land, and the vineyard records Nos. 4, 5, 6, 7, and 8 show that the sandy loam of the surface extends down to a depth of from 6 to 8 feet before reaching the clay loam. In the Muscat vineyard in charge of Mr. Hager and in the Berger vineyard of Mr. Gerken, both a short distance northwest of Orange, I have dug to a considerable depth and found only a loose and perfectly drained sand. The former vineyard is worthless and the latter died in the summer of 1889. In vineyard No. 4, at Westminster, the soil is a sandy loam running into a quicksand at a depth of about 8 feet. This vineyard died in 1888. In portions of the 2,300-acre Nadeau vineyard at Florence, at San Gabriel and Pomona, observations of a similar nature were made. At Pomona the vineyard of Mr. Mirande has, near his residence, a sedimentary, sandy, and gravelly soil. This is uniform to a depth of about 10 feet. The vines are badly diseased at all the places mentioned, especially the Mission vines in both the Nadeau and Mirande vineyards. The 800 acres of medium-aged and vigorous Missions of the Nadeau vineyard had, during August, 1889, a general yellow cast to

the foliage, in marked contrast to the appearance of the adjoining vineyards of more hardy varieties.

Porous subsoil.—For the study of the effects of a porous or open subsoil on the disease, there could be no more illustrative region than that stretching from the east to the north and northwest of Orange, and generally known as *the gravel land.* Several thousand acres of land, mostly of a marked gravelly nature, border both sides of Santiago creek. Toward the creek the subsoil becomes coarse gravel, running in many places into what is almost a bowlder bed at a few feet from the surface. The records of vineyard No. 14, belonging to Robert McPherson, show the gravel to extend to a considerable depth, and its owner says the proportions of soil to coarse gravel become less and less as the depth increases. Vineyard No. 1 is also situated on this belt, on a gravel soil mixed with clay, which extends to a depth of at least 50 feet. These vineyards died in 1887 and 1888. A ditch dug across this gravel land reached much coarser material at the bottom than was found at the surface. It is stated that on this land half an acre of alfalfa would absorb a flow of "one-half head" of water for a week without allowing any water to flow beyond its borders.[1]

These examples are cited to show that the most perfect subsoil drainage has not in the least retarded this disease, for over this tract of most thoroughly drained land, formerly supporting hundreds of acres of healthy, productive, and profitable Muscat vineyards, there exists at the present time scarcely an acre producing sufficient fruit to pay for the labor of cultivation. Other conditions being equal the vines have died earlier and more uniformly in this location than where the subsoil was more retentive of moisture.

Artificial drainage.—In this sloping country few ditches are dug or drains laid for the sole purpose of draining the soil. Even on the artesian and often alkaline belts, where underdrainage might materially aid in keeping down alkali, tile or other subdrainage systems do not appear to be extensively in use. It is sufficient here to speak of those vineyards through which the very perfect systems of irrigating ditches are run. The lateral ditches into which water is only admitted when irrigation is in progress furnish unexcelled opportunities for observing the effects of artificial drainage upon the vines lying near the drains. The result has been uniform. In no case have such drains saved a vine. It will be found, however, that between these drains and the first row of vines there is usually a strip of unoccupied ground, and it is customary to plant the blue gum (*Eucalyptus globulus*), the pepper, or other trees near these ditches. To make a perfect test of the effect of drainage these conditions should not exist. The outer row of vines has a greater body of soil to draw its nourishment from than the interior rows, and when trees are planted the vines and soil are often

[1] A "head" of water is here considered to be the amount passing through an opening 33⅓ inches wide and 3 inches high under a 4-inch pressure.

shaded, both conditions aiding materially in prolonging the life of the vine.

In concluding this portion of the subject it may be said with confidence that neither surface drainage, a loose soil, a porous subsoil, nor drainage by artificial means will prevent the introduction of the disease or hinder it in its spread and work of destruction.

RELATION OF IRRIGATION TO THE SOIL.

Vines of nearly all varieties are grown with success in southern California under four distinct general conditions: (1) On uplands with irrigation; (2) on uplands without irrigation; (3) on lowlands with irrigation; (4) on lowlands without irrigation.

Irrigated uplands.—A large percentage of the Muscat vineyards of Orange County have been grown under this first condition. As these have been wholly swept away by the disease, and they were the ones which formerly attracted the greatest attention in that region, the idea has been advanced that the practice of irrigating or submerging is at the bottom of the trouble. Among others who have held this view is Mr. T. V. Munson, of Denison, Tex. I take the liberty of inserting here a statement of this gentleman which, under the conditions observed by him, might seem to give a possible explanation of the origin of the disease. Mr. Munson made a trip through California during 1889 and observed the disease as it prevailed in certain districts. When at San Gabriel he saw a vine, a chance hybrid of *V. vinifera* with the native "*V. Girdiana*," badly diseased, but he does not remember having observed wild vines diseased elsewhere. The southern Californian wild species was always found where, in ordinary seasons, it could reach permanent moisture with its roots.

At Mr. Gird's place, some 8 miles northeast of Fallbrook, we found his vineyard located in a valley where there is always permanent moisture some 4 or 5 feet below the surface of the soil. He had many varieties of *V. vinifera*, as well as plants of several of our native species, among them a vine of *V. Californica* Benth., from the Sacramento Valley, and near about in the same valley were numerous plants of my *V. Girdiana*, all the perfect picture of health.

At many other places in southern California we saw both young and more especially old vineyards more or less affected with the disease. In all these cases the vines grew in soil where no native grape had grown wild and which without irrigation dried out very deeply, so that no vines could survive, but where irrigation had for a time given excellent results.[1]

We examined vines at National City some 3 to 5 years old, recently showing the disease, and found the first effects showing in the deep-feeding *root fibrils* in becoming browned in part or whole, the cuticle readily slipping off, as though the sappy cells beneath had decayed by being inhabited by bacteria, which had eaten out the starch, etc. We did not examine for bacteria, having no microscope, but I infer their presence from the similarity in appearance with the feeding fibrils of the cotton and other plants in this country affected with the "cotton-root blight," which Prof. L. H. Pammel, now of Ames, Iowa, has been studying for the past two seasons.

[1] See under the head of "Nonirrigated lowlands," p. 88.

It has occurred to me as a probable theory that the great extremes of dryness and moisture, obtaining in irrigated lands in southern California, has something to do in inducing the disease. The vines during very dry times, or when not irrigated for a long time, send their feeding roots very deeply, and when the ground is saturated (oversaturated often) by renewed irrigation the deeply feeding fibrils are drowned and the ever-present bacterial scavengers enter and devour not only the dying, but, when once in, the living tissue of the plant, and that, probably, when the tissues of the vines are once inoculated with the bacterial germ, the plants grown from the affected vine will have the disease under any circumstances. In other words, the disease has become infectious, probably, as indicated in young vineyards in most favorable localities soon showing symptoms, even in the first or second year.

Further facts may show that my theory is totally incorrect. I propose it only as a line of investigation. Doubtless you have been all over the same line already and my theory is already exploded.

Had Mr. Munson's observations extended to all the affected regions of Los Angeles County and the Santa Ana Valley, the grounds for the above statements would have probably been changed.

The water for irrigating the vineyards on the highlands in southern California comes from several distinct sources. The principal one for the raisin district of Orange County is the Santa Ana River. In that portion of the Santa Ana Valley where vines first died there are two irrigation districts, the Anaheim district on the north and west and the Orange and Santa Ana district on the south and east of the Santa Ana River. Both derive their water from that stream. Main and secondary ditches form a network over all this region, and vineyards are irrigated in accordance with the ideas of their owners. The general practice is and was to allow a stream of water to run between the rows long enough to thoroughly saturate the ground, and in many cases vineyards became more or less flooded. Many modifications of this system are found in different places. At Riverside I have seen a square box extending along the side of the vineyard, and from it water escaped through inch holes, running down between the rows until the vines are thoroughly but not over-watered. This resembles a Sicilian system.

Above the Anaheim and Orange irrigation districts are others also deriving their water from the Santa Ana River. But the vines of these upper districts, although nearer the source of water supply, are dying much later than those lower down. In fact, the disease develops later and later as we pass up stream.

Thus far there is no good evidence that disease has in any way been introduced through this water supply, for thousands of acres of vines have died which never received a drop of Santa Ana River water and hundreds of acres are still bearing which have always been irrigated with it. Vineyards at San Juan Capistrano and a large percentage of those in Los Angeles County have perished from the disease, and they never received any of this water. Nearly every stream coming from the mountains is used for irrigation at one place or another, yet there is no apparent difference in the effect upon the vines. When the vines

become diseased they die, other things being equal, under one system of irrigation as well as under another.

It has been the practice with some vine-growers to irrigate in the winter, with others in the summer. Vineyard No. 1 is an example of Muscat and Sultana vines which had been irrigated only in winter after the first year. Twenty acres were set in 1881, 10 acres in 1883, and 2 acres in 1885. Disease appeared here distinctly in 1886, and the leaves became spotted and dropped prematurely. In 1887 2 per cent of these vines died; in 1888 nearly all of them were dead. They were all taken out in February, 1889.

J. F. Bennett's Muscat vineyard, north of Orange, received summer irrigation and died in three or four weeks afterward. There was a Muscat vineyard at Riverside, belonging to A. M. Aldrich, set in 1884, which was rapidly dying of the disease in August, 1889; yet the vines had been irrigated twice that summer, first in the middle of June, and again July 25. Another vineyard at Riverside with many badly diseased vines was irrigated about May 5, June 17, July 10, and August 4, 1889. The water ran for forty-eight hours, and judging by the appearance of the vines the disease had been there since 1887.

Non-irrigated uplands.—Numerous vineyards in Los Angeles County, although they had little or no irrigation and were located upon high ground, have died. This is true of different varieties. In Orange County most of the vines on the dryer grounds have been irrigated. In San Diego County, especially about Fallbrook, they are largely grown on a granitic soil in a high situation without water, but up to the time of my visit the disease had not developed far enough to admit of fair conclusions as to what would be the ultimate results.

Irrigated lowlands.—On some lowlands it has also been customary to irrigate, often with artesian water. C. M. Head, of Garden Grove, had Mission vines which had produced well and were irrigated with artesian water from two to three times each summer. These are all dead. The same might be said in respect to nearly all the vineyards on artesian ground in the Santa Ana Valley which have been irrigated.

Non-irrigated lowlands.—We have now to note the results observed in the lower parts of Orange and Los Angeles counties, where vines have been set on either artesian ground or on that having water so near the surface as to give permanent moisture for the roots. If vines have died as completely on lands never irrigated and where permanent moisture may be reached by their roots the year through as they have upon irrigated lands, there seems no good reason for supposing conditions induced in the soil by irrigation were the direct cause of the disease.

In June, 1889, I saw vineyards in the Santa Ana River bottom northwest of Orange which were worthless and a large percentage of the vines were dead. Close by the wild vines were growing in thrifty clumps, spreading out over the sandy land to a considerable distance. Here the disease was killing European vines on ground containing abundance

of water for the thrifty growth of native vines. Hundreds of acres of vines growing in the lowlands about Los Angeles, where permanent moisture is reached at a moderate depth, have died, and thousands of acres more are rapidly dying. West of the Santa Ana River, in Orange County, and to some extent east of it, is a considerable expanse of territory where artesian water rises from a few inches to many feet above the surface. Over this region were scattered vineyards of many varieties of both wine and raisin grapes. They were at Garden Grove, Westminster, Norwalk, and other places, and included many hundreds of acres never irrigated. The roots of these vines could always draw from permanent moisture, which varies in the depth at which it is reached from 3 or 4 feet to 10 or 12 feet, according to location. Probably at the present time not 10 per cent of all the vines, young or old, hardy or susceptible, are left to indicate that vines were ever grown in this region. In some places the only remains to be found are in the woodyards behind the houses, where in 1889 piles of vine stumps were generally to be seen.

Vineyard No. 4, with five varieties of grapes, Mission, Black Hamburg, Muscat, Flaming Tokay, and Almeria, was at Westminster, on sandy loam running into a quicksand at a depth of 8 feet. Permanent moisture is found at this depth, while artesian water flows many feet above the surface. These vines had never been irrigated; they were planted in 1874, had always borne heavy crops of grapes, and produced a thrifty growth of cane. They are now all dead from the effects of the disease.

T. H. Powers, of Garden Grove, had 4 acres of young Muscats set in a black sandy loam in the spring of 1886. They produced a few grapes the first season, half a crop in 1887, only 500 pounds per acre in 1888, and only enough for home use in 1889. Some of the vines were removed to allow of the planting of corn in 1889. This yielded at the rate of 40 to 50 bushels per acre. Permanent moisture is reached here at a depth of 4 feet, and the entire region is supplied with artesian water having a head of from 2 to 5 feet. This water is reached at one place at a depth of 140 feet. D. A. Baker, of Garden Grove, had a vineyard of Flaming Tokays which were rapidly dying in 1889. This vineyard had never been irrigated and, like the preceding, was close to permanent moisture and on artesian ground. A. Porteous, of Garden Grove, had a vineyard of Mission, Muscat, and Zinfandel vines. These vines were not irrigated and died in the order given. The land is fertile and permanent moisture is close to the surface, and Mr. Porteous said that vines bore better in dry than in wet seasons, which would indicate an abundance of water in the dryest years.

On the place of Mr. D. B. Chaffee the soil is a rich black sandy loam and quite level. He said that water had not failed to rise above the surface in his artesian well for five years. His vines were mostly of the Muscat variety. They had never been irrigated, not even when

first set out, and he said he had never seen finer or more thrifty vines before the "blight" struck them. Besides the Muscats there were some seedless Sultanas and Flaming Tokays. The resistance of these varieties was in the order given. Dr. J. Warner, of Garden Grove, had a Muscat vineyard which he never irrigated. The older vines were set about the year 1877. The old vineyard was upon a rich, deep, fine sediment. This soil is exceedingly strong and especially adapted to grape culture. But even here, with permanent moisture close to the surface, the vines died as surely as upon the more sandy soil at the northwest. They bore a heavy crop in 1885, 70 per cent of a crop in 1886, only 200 pounds in 1887, and were taken out in 1888.

Dr. J. D. Chaffee, of Garden Grove, had a Muscat vineyard which bore a heavy crop in 1884. The soil is a dark sandy loam to a depth of 4 feet, where it becomes a coarse sand. His vines were 13 years old in the winter of 1889, and the land had produced two crops before the setting of the vines. The vineyard died from the disease and was removed before November, 1889.

Although these records might be almost indefinitely extended, enough has been said to show that the death of the vines is not directly connected with irrigation or with lack of permanent moisture in the soil. Many hundreds of acres of vines have died which had permanent moisture and were never irrigated.

RELATION OF IRRIGATION TO THE ATMOSPHERE.

There is one other feature of this subject worthy of consideration. What was the secondary action of irrigation in producing a widespread death of vines? Has it induced new and important atmospheric conditions which have been directly incompatible with the health and life of the vine or which have increased the development of some parasitic growth? These questions can not now be fully answered, as they of necessity involve the solution of the entire problem. We may, however, consider the probable bearing of irrigation as far as the facts in hand will warrant.

Direct action of atmospheric humidity.—As has been shown, Anaheim is within a district where irrigation was commonly practiced. The oldest vines were planted in 1858 and 1859, and had in general been irrigated. This vine region was extended farther and farther year by year, and the majority of the new vineyards were also irrigated. All had lived, grown, and produced fruit according to their situation and care, and such a thing as the entire or general death of a vineyard was unknown. There were some instances where Mission vines became more or less unprolific and unprofitable and were replaced by young or different stock, but this was in no sense due to a specific disease. Prior to 1884 vines had been grown over an extensive region under irrigation for a period of over twenty-five years, and these vines were largely of that

variety most susceptible to the present disease. It is also a fact that nearly every one of these Mission vineyards was dead in 1887, killed within a space of three years. If irrigation has in any way caused the death of these vines, then some radical change must have occurred about the year 1884, but no evidence of such a change has been brought to light. An increase in the amount of irrigated land has certainly taken place, but this was also true during the entire period of healthful growth of the vines. If the increase of humidity caused by the increase of irrigation culminated in 1884, or thereabouts, sufficiently to cause the death of the vines in that region by some disease allied in its action to Folletage or sunstroke, it still remains to be explained why vines have died from the same malady in distant valleys where this local influence has never been felt, and why young vineyards have died which were set since the valley was denuded of its vines, and this extended irrigation has been somewhat reduced.

Indirect action of atmospheric humidity.—It is under this head that the more difficult problems arise. Has the increased atmospheric humidity due to extended irrigation caused a rapid increase in parasitic animal or vegetable forms, which have spread out from this valley as a center and which still persist? Such an effect would harmonize with the bulk of observations in the field, but such a secondary cause does not seem to fill all the requirements of the case. Irrigation had been practiced at Anaheim for twenty-five years, and no such results had followed. In other regions now affected by the disease it was practiced for a longer period and up to a later date than 1884, but no disease had developed to produce such results. Irrigation has also been practiced in other parts of the State and the vines have not failed.

The fact that vines had been irrigated without serious effect for twenty-five years at the point where they first began to die is of the most importance, for when other regions are considered it may justly be said that the local climatic conditions of the Santa Ana Valley do not exist elsewhere. Hence the results have not necessarily been the same, but have been modified by their own local peculiarities. Comparisons with the results in foreign countries would be equally as defective, and for the same reason. It is true that in several foreign countries various methods of irrigation have been practiced, and under such treatment vines have always prospered. Some of the older and more profitable vineyards of Spain have always been irrigated. In Sicily, though irrigation is not required as it is in California, it is practiced to some extent, and with no bad results. The same is true for a century of irrigation at Parras, Mexico.

The whole subject may be summed up as follows: (1) Irrigation is not a necessary or constant accompaniment of this disease, so far as soil effects or conditions are concerned; (2) permanent moisture within easy reach of the roots will neither prevent the disease nor save the vines when affected; (3) irrigation does not satisfactorily account for

the death of vineyards by Folletage or sunstroke through increasing the humidity of the atmosphere; (4) irrigation under existing conditions does not explain in an entirely satisfactory manner why any parasite should suddenly become epidemic among the vines with sufficient virulence to annihilate the vineyards of this large region; (5) there is no evidence that germs of disease have been introduced into the vineyards from any special source of water supply.

SOIL POVERTY.

Prof. Scribner, after a visit to southern California in 1887, says:

> It is folly to talk of impoverished soil in this locality—a glance at the surrounding vegetation is sufficient to convince one of this.

After a careful review of the region where this disease exists, it seems as if this conclusion was the only one possible. It is due, however, to those who hold an opposite opinion that impoverishment of the soil should be carefully considered as a possible cause of the disease. To those who have not been in southern California this might seem a possible *vera causa*.

Artificial fertilizing.—There are many cases throughout the diseased region where artificial fertilizers have been mixed with the earth to such an extent as to greatly increase the natural fertility of the soil. One instance of this is on the ranch of Mr. J. Willets, formerly owned by H. H. Roper, and situated 1¼ miles southwest of Santa Ana. The 16 acres of Muscat vines had produced exceedingly heavy crops, equaling, in fact, the yield of the best vineyards in the State. The soil is a deep, rich, sandy loam, and the cause of the great yield of grapes can be traced to the conditions outlined below. During the time when the Mexicans occupied this region extensive herds of cattle were pastured throughout the entire Santa Ana Valley, especially along the artesian grounds bordering the Santa Ana River. The cattle belonged to San Juan, the Santa Ana rancho, etc., and were raised for their hides and for tallow, both of which were shipped in great quantities from the neighboring seacoast. At one point the Mexicans had their corral, slaughter grounds, and accommodations for drying hides and trying out tallow. Here the cattle congregated and were slaughtered each year in large numbers. As a result the ground became saturated with blood and filled with refuse from the kettles, and the bones and droppings of thousands of head of cattle. As tallow and hides were all or nearly all that could be marketed, an immense amount of refuse was added to the soil. The soil is here naturally rich and productive, and the addition of these fertilizers resulted in forming an exceedingly rich and strong substratum. Upon this slaughter ground the vineyard was set out, and the bones still lay about in fragments between the remaining vines, as was learned by a careful personal examination in the sum-

mer of 1889. The size of the vines testified to their past vigor. This ranch is upon the edge of the artesian belt, and permanent water is found but 5 or 10 feet below the surface. Near the vineyard is an artesian well which delivers water from 1 to 2 feet above the surface. This water is not allowed to pass over this portion of the cultivated ground, and no bad effects from alkali are produced, yet in this wonderfully rich and favorable situation the entire vineyard died from the effects of the disease. Most of the vineyard has now been removed, and only a few lingering vines, mostly Flaming Tokays, were alive in 1889. Here was an exceedingly fine vineyard, which had for years produced very heavy crops, dying in its prime and within a period of two or three years, on ground thoroughly fertilized with the richest of plant food, phosphate of lime.

Mr. C. Meyerholz, formerly of Anaheim, informs me that he had thought at first that some of the vineyards had been burned with manure. He says[1] that some of the vine-growers procured sheep manure from the corrals at the foothills and treated their vines with liberal quantities. When the vines began to die he thought they had been burned with this heating fertilizer. The result is sufficiently convincing. All these old Mission vineyards are things of the past, not one remaining at Anaheim to show the effects of sheep manure or of any other treatment.

At Tustin a Muscat vineyard belonging to Mr. J. N. Smith was situated on the site of an old sheep corral where the ground was very rich. The owner states that the vines lived longer on this ground and were more vigorous than on neighboring places. But all eventually died of the disease like those on ground not artificially enriched.

The direct effects of fertilizing several varieties of diseased vines with sewer water has been observed near Los Angeles. Mr. W. D. Whelan had a Muscat vineyard, which, in some places, had been flooded with sewer water to a depth of 6 inches. When examined, these vines were somewhat diseased throughout the vineyard, and the untreated were worse than the treated, which, under any conditions, might be anticipated. The result at the time was uncertain, for disease had not advanced very far, but Mr. Whelan has since been obliged to remove the vineyard. Across the street from this place was a vineyard seven or eight years old of the less hardy Mission, and of other varieties, where the disease was more marked. Here the sewer water had had full play over the ground. At the time of my visit in 1889 the Zinfandels showed very little signs of disease. The Malvoisies were distinctly marked with the red leaves and the Muscats were in about the same stage of disease. The Mission vines were nearly dead. Here the progress of the disease varied according to the hardiness of the variety,

[1] Letter dated Santa Clara, September 15, 1889.

and from the fact that one variety was already nearly dead it is evident that fertilizing by means of sewer water can only be considered of value to postpone the ultimate result of the disease. Of course there may be other conditions tending to modify these conclusions.

At Anaheim some large Isabella vines, which had grown in a hen-yard, were wholly dead from the effects of the disease. Near San Gabriel old Mission vines have died while growing at the side of a stable; and were it needed an indefinite number of facts could be cited from all over the diseased district. Hundreds of arbor vines have died, for example, at the back doors and in the highly cultivated gardens over the whole region. Mr. Roper, of Santa Ana, gave his arbor Catawbas special care, with the hope of saving these at least, but all are dead.

The use of fertilizers seems to strengthen the diseased vine, and to enable it to more readily procure the required amount of nourishment with its reduced number of roots, which gradually decay and leave fewer and fewer to nourish the plant. But when the disease first appeared vines could not be saved by any amount of artificial fertilizing used either as preventive or cure. At the present time, after the greatest virulence of the disease has passed, the effect of fertilizers, especially upon those vines naturally the most resistant, is more obvious, and may carry a vine over disease for a considerable length of time. But because fertilizers may benefit, it does not follow that want of fertilizers is the cause of the disease. Especially is this true when before the advent of the disease the same plant had prospered for a century on unfertilized ground, and now new vineyards set close by on new soil have died.

Natural fertility of the soil.—Gustav Eisen, in his recent and valuable work on the raisin industry,[1] says:

> A rich alluvial deposit is found in Orange County, in the fertile district known as the Santa Ana Valley. The soil around Anaheim, Santa Ana, Orange, and Tustin consists of a more or less dark alluvial loam of unsurpassed fertility, and especially adapted to the Muscat grape.

Mr. Eisen also states that the best yield of the Malaga vineyards of Spain is 8 or 9 tons of grapes to the acre. But vineyards which have died from disease in the Santa Ana Valley and elsewhere have produced even more than this up to within one or two years of their death. Soil poverty could not induce an abnormally abundant yield, and if this productiveness be not due to the stimulative action of a specific disease it must be due to the native fertility of the soil. An arrival at either conclusion is sufficient to prove that soil exhaustion is not the cause of the disease or of the death of the vines.

Mr. S. G. Baker's vineyard, at Norwalk, yielded 10 tons of grapes per

[1] The raisin industry. A practical treatise on the raisin grapes, their history, culture, and curing. San Francisco, 1890.

acre three years before its death. A. Reuter's Muscat vineyard at Santa Ana yielded 8 tons of grapes per acre three years before its death. His Berger vineyard yielded 9 tons per acre two years before its death. A vineyard north of Anaheim yielded 12 tons per acre shortly before its death.

Hundreds and hundreds of acres of vines have produced the usual yield on new land or virgin soil two or three years before their death. Not all yields have run as high as those given, for such productiveness is exceptional in California as well as in Spain. Personal observation has shown that the yield of vines in California is equal to, if not greater, than that of vines under similar cultivation in any of the finest vine-growing regions of France, Italy, Sicily, or Algeria. Among the most magnificent European vineyards in the fertile valley back of ancient Syracuse there are no finer bunches or more prolific vines than those of southern California.

Vines have died from this disease in less than three years from cuttings set in soil never before planted to vines. Abundant crops of all kinds of cereals have been produced upon ground which had been cleared of dead vines the preceding year. Forty bushels of corn has been grown per acre on such land. Soil that will produce corn 10 to 20 feet high is not soil upon which grapes will die from starvation in the course of four or five years. In one dead vineyard Malva grew so rapidly as to stand in a short time almost uniformly higher than my head. In many places the weeds have to be cut with a scythe after the rains to make it possible to plow.

These facts illustrate a few of the lines of evidence of the remarkable fertility of the soil in districts where vines have died. There is scarcely a place in the affected district which has not its own history of wonderful yields in some branch of agriculture or horticulture. The chemical side of this question will be briefly considered in one of the following sections.

SOIL CHARACTERS.

It is difficult to formulate anything approximating a law governing the development of disease in different soils, for modifying conditions, such as elevation, moisture of the soil, and the age and variety of the vine are numerous and combined in many ways. There is perhaps no place in the country where soils vary more in their general and physical characters than in southern California.

Throughout the Santa Ana Valley as well as in the valleys further north, the general trend of the surface formation is from northeast to southwest, although this is modified in some places. This trend is without doubt due to the direction of the natural watershed of the region, which is mostly parallel. The greatest variety of soils is found by crossing these washes along a line extending from the southeast to the north-

west, and the effect of this variation of soil upon the disease is often well marked in the vineyards. It has given rise to some theories as to the spread of the disease, and has furnished a basis for comparison as to its effects in different soils. In certain vineyards, where these variations of soil occur, the disease has developed more rapidly upon one than upon another. When most rapid development has been at one side or at one corner of a vineyard it has looked as if the disease was progressing from that portion of the vineyard or the corresponding point of the compass. This is so well marked in some cases that, judging from individual vineyards, one could believe in the progress of the disease from almost any direction. In some places seen the variation of soil was so gradual that the eye only detected it by the more marked signs of disease in certain directions. The vines will show the change when the eye will overlook it in the soil.

In general the soils of California may be grouped for consideration in relation to the vine disease under three heads: (1) Heavy soils, including the red and black adobe and clay soils; (2) The gravelly soils; (3) The fine loose soils, including the sandy loams and the sands and fine sedimentary deposits of the river bottoms. The uplands are largely composed of heavy soils, which skirt the foothills.

The heavy adobe and clay soils are most frequently found upon the mesas and adjoining foothills and are exceedingly strong and productive. The adobe soil has some peculiar qualities. When dry it becomes hard and compact, and if not properly cultivated will often adhere in cakes of greater or less size. During the heat of the season on poorly cultivated ground it often cracks to a considerable depth. On the other hand, during the season of heavy rains or after being irrigated, this soil be comes entirely plastic and wholly loses its supporting qualities. The location may be high and the surface drainage perfect, yet it is not uncommon for teams to become mired if they have ventured out of the beaten track and into the open field.

Prior to the appearance of the disease vines set on soils of this kind did well, but they required more careful cultivation shortly after the rains to prevent the soil from caking, and a consequent loss of moisture through capillary action, but where this has been attended to the vineyards have prospered. I have observed, however, that vine roots when once diseased decay much more rapidly and completely in soils of this character than in those of a lighter, more friable and sandy nature. Hundreds of acres have died on these heavy soils.

Gravel soils do not here include those soils approaching sand, but those having a distinctive gravelly nature. They are quite extensive in the Santa Ana Valley. Other conditions being equal vineyards situated on these soils have died from the disease, as a rule, earlier than upon other soils. The following causes undoubtedly aid in producing this effect: They retain less moisture; they are warmer, and have, as a rule,

less abundant supplies of plant food immediately accessible to the roots of the vine. Many hundreds of acres of vines of all ages and varieties have died on this coarse class of soils.

The fine, loose, sandy, and sedimentary soils are found composing the greater part of the river bottoms and adjoining plains throughout the worst affected parts of southern California. The fine soils are as apt to vary in their nature as those of the heavy class. They comprise a coarse sand of little fertility, a fine river wash or sedimentary sand, which is in some places quite deep and very fertile, and several qualities of loose, sandy loams. Upon all these soils the vines have died by hundreds of acres. The observations made would indicate that where other conditions are similar the disease can not conquer a vine or vineyard as quickly upon a loose, sandy soil, which is level, as it can on heavier soil. Many observations seem to contradict this statement, but special interpretation must be given all the cases upon which other statements are based. Where fertility and looseness of soil are combined the vines will live much longer than upon heavier soils of equal fertility. It is a decided advantage for roots to be able to push rapidly into new substrata. Roots shoot out easily in loose soil, and if the latter be fertile the vines exist much longer than the roots could sustain them upon a heavier soil.[1] Where there is no drainage due to local elevation this loose soil also retains water readily.

The apparent exceptions to the advantages of sandy soil are mostly where local swells or ridges exist and where underdrainage has lessened the moisture. The records of the eighteen vineyards tabulated in the first part of this chapter show the results of the disease on quite a number of soils, and an indefinite number of such records could have been obtained had it seemed necessary or desirable to have them.

In arriving at the conclusions already noted comparison has been made between large tracts of vines grown on soils of these three classes, although special vineyards on each kind have received careful attention. Examinations of the conditions of the roots in the three situations were made when large numbers of vines were being removed from the ground. Variety and age have been taken into account as well as the general surface conditions.

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[1] These facts have become proverbial in respect to the workings of Phylloxera in the southern and western departments of France. Within a mile of the city of Montpellier is a vineyard in a low sandy spot where the vines were yet thrifty in 1890, though of the original ungrafted stock of the region. The great bulk of vineyards of the Hérault have been growing on resistant stock for a number of years. This same fact is plainly illustrated through all the Mediterranean region of France as well as in the vicinity of Bordeaux. In Sicily the same conditions are evident. At Faro the vineyards still exist on the sandy point, while they have been almost wholly stripped from the back-lying hills. The vineyards of the plain of Catania are all infested with this terrible scourge, and are only saved by a thorough and systematic use of the bisulphide of carbon. It may be interesting to state, also, that

Probably the most illustrative region, though not the only one which has been seen and considered, is that lying between Norwalk and the foothills east of Orange. There is here much land belonging to the fine, the gravelly, and the heavy classes of soils. On the gravel land nearly every vineyard is wholly dead and most of the stocks are removed. On the heavy adobe soils near the foothills a number of vineyards were still lingering as late as the winter of 1890. On the sandy lands northwest of Orange and at Norwalk numerous vineyards produced light crops in 1891. It is true, Anaheim is situated on sandy land and was the first place to be stripped of its vineyards. But there are several reasons which may be assigned for this. Among them are early infection, age of vine, comparatively infertile condition of soil in some of the older vineyards, and the fact that the disease worked more strongly and rapidly at this center where the vines were of the most susceptible variety and very old, and where such conditions extended over a large area.

It is not to be expected that these conclusions will be in accord with the observations of all vine-growers, for there are many apparent exceptions to the rule. It is true that sandy corners or elevated ridges sometimes show disease earlier in a vineyard than more heavy soils; but this is almost invariably due to infertility of the soil or slight elevation admitting of more rapid drying out by subdrainage.

If conditions of age and variety are the same, the power of any vine to resist disease is about as follows upon the three classes of soils: (1) Least resistance upon coarse gravelly soils; (2) medium resistance upon soils of a heavy and compact nature; (3) greatest resistance upon level soils which are loose and sandy but not infertile.

SOIL ANALYSES.

Analyses of earth from affected regions have not thus far been made in connection with this investigation. But soil taken from among dying vines at Anaheim, by F. W. Morse, was analyzed at the chemical laboratory of the University of California. There was no direct clew

plans are being considered for submerging these vast and productive vineyards with a hope of conquering the insect in this way. Some limited tests have already been made and the results are being watched by Prof. Aloi, of Catania. The outcome seems to be a matter of considerable doubt. The conditions at Catania are very favorable to a thorough test for that section, as the river Simeto, which has an elevated source on Etna, passes through the vine region almost unused, and it furnishes unexcelled facilities for irrigating purposes. Vines in the more sandy soils are least affected. At the south, in the province of Syracuse, and as far down as Noto, Phylloxera is widespread. All along the firmer lands near the coast between Syracuse and Noto, the vineyards are in a wasted condition, but through the sandy regions back of the city of Syracuse and as far as Floridia, they are in better condition, those upon sand or very loose sandy loam presenting a most attractive appearance.

gained to the nature of the disease by this analysis, but the results of the examination are given here for those who desire to know the constituents of the soil in which vines have succumbed to the disease. This will be followed by analyses of soils from Redlands and Cajon Valley, by the same institution, which will afford a means of comparison. Since the analyses of Anaheim soil were made, the disease has developed on all kinds of soil and upon those of undoubted fertility and adaptation to the growth of the vine. These conditions were not so well marked when the first test was made.

Analysis of soil from a dying vineyard at Anaheim, Cal., made at the chemical laboratory of the University of California.

	Per cent.
Coarse material	2.2
Fine earth	97.8
	100.0
Insoluble residue	69.841
Soluble silica	11.404
	81.245
Potash	.796
Soda	.318
Lime	2.042
Magnesia	1.915
Br. oxide of manganese	.051
Peroxide of iron	3.155
Alumina	7.557
Phosphoric acid	.077
Sulphuric acid	.005
Water and organic matter	2.696
	99.857
Humus	.521
Available inorganic	.523
Hygroscopic moisture	2.970

Absorbed at 16° C.

The best commentary upon this analysis is given in Mr. Morse's own words. His visit to the diseased vineyards was made in the summer of 1886, before the disease had extended to any marked degree far from Anaheim. He says:[1]

As there have been evidences in the older vineyards pointing to some trouble in the constitution of the soil, a sample was taken from the central part of one of the "bad spots," at a depth of 20 to 24 inches, this representing the portion of the land most heavily drawn upon by the grape roots. * * * The analysis [above given] reveals no special defect in inorganic constituents of the soil. Potash is present in large quantity; lime is abundant, and in sufficient proportion to render all the essential ingredients readily available to plant growth; phosphoric acid is up to the average of southern California soils. The per cent of inert insoluble matter is quite high, but this is counterbalanced by the looseness and by the depth of the soil, thus

[1] Report of the viticultural work of the college of agriculture, University of California, for the years 1885-'86. By E. W. Hilgard. Pp. 178-179.

making up in volume what is lost in strength. The sandy character points to an easily drained soil, and its deficiency in clay places it among those poorly adapted to retaining moisture. The hygroscopic moisture per cent is quite low, showing that the land can not stand long and continuous drought. This is of special importance in the trouble affecting the vines at the present time.

In order to determine the amount of water at hand for the immediate supply of the vine, a sample of soil was taken from the same spot and depth as the analyzed specimen, carefully sealed, and the water determined at 100° C. It amounted to only 4.62 per cent, which, taken with the water in the hygroscopic moisture determination which would not be lost at this temperature, would give a very small amount of moisture for immediate use.

The bad spots, long supposed to be due to alkalinity of the soil, contain only .036 per cent of alkaline carbonates at a depth of 24 inches. If the soil had been taken nearer the surface, at that time of year, the per cent would doubtless be increased. It is scarcely sufficient to produce sudden or decided bad effects, but in the course of time may injure the growth of the vines by its action upon the smaller rootlets.

The roots examined show very little effects due to this cause, although there were spots examined some years before, which show undoubted injury due to alkali. The amount of humus exceeds that which would be expected from a soil taken at this depth, being a fair average for soils taken nearer the surface, and, in fact, exceeds the amount found in the upland soils. Its distribution at such a depth is doubtless due to the alkali, which keeps it in solution and easily carries it down through the porous soil.

In 1884 the California Agricultural Society published analyses of soil from southern California.[1] One of these was of the red soil from Redlands, together with its subsoil of hard pan. The results are given below:

Analyses of Redlands soil.

	Red soil, 12 inches in depth.	Hardpan subsoil 3 to 4 ft. deep.
Fine earth	57.9	81.2
Coarse sand	42.1	18.8
Analyses of fine earth:		
Insoluble matter	69.56	67.14
Soluble silica	11.82 } 81.38	10.81 } 77.95
Potash	.85	.32
Soda	.11	.40
Lime	1.34	1.44
Magnesia	1.11	2.58
Br. oxide of manganese	.08	.07
Peroxide of iron	3.46	4.86
Alumina	8.87	10.08
Phosphoric acid	.06	.06
Sulphuric acid	.01	.03
Water and organic matter	2.69	3.00
Total	99.96	.....
Humus	.37	.....
Available inorganic	.27	.....
Hygroscopic moisture	3.37	5.86
Absorbed at	12° C.	12.5° C.

These soil analyses are commented upon by Prof. E. W. Hilgard, under whose auspices they were made, and his views are embodied in the following quotations:

Chemically the surface soil is rich in potash (so heavily drawn upon by vines), while the hardpan is relatively poor in that substance. The lime percentage is the

[1] Annual report, pp. 183–199.

same in both, and is ample. In phosphoric acid both alike are above the limit of deficiency, but the supply is not large, and will probably be the first needing to be replenished when the soil becomes "tired." Still, in view of the depth and perviousness of the subsoil, it may be long before this condition will make itself felt in the case of deep-rooted plants, such as vines and fruit trees. Two other soil varieties are found in the colony, differing from the one analyzed mainly in the greater proportion of sand, which in one case is very coarse. The latter overlies the hardpan to the depth of 4 feet, and is reported to have shown an especially thrifty growth of vines planted, though the latter have done well on all. Probably for the first year, at least, the thriftiness of the vines will be in direct proportion to the depth of the surface layer of soil.

Samples of red soil and subsoil from El Cajon valley were analyzed by the same authority, and the results are given in the report of the same society. They are as follows:

Analyses of red soil and subsoil, El Cajon valley.

	Soil.	Subsoil.
Coarse sand	20.00	25.5
Fine earth	80.00	74.5
Analyses of fine earth:		
Insoluble matter	83.404	71.900
Soluble silica	3.805	87.209	8.143	80.043
Potash	.729	.670
Soda	.290	.188
Lime	.775	1.028
Magnesia	.692	1.340
Br. oxide of manganese	.063	.054
Peroxide of iron	4.358	7.392
Alumina	4.167	5.988
Phosphoric acid	.053	.054
Sulphuric acid	.069	.011
Water and organic matter	1.913	3.081
Total	100.318	99.849
Available inorganic	.334	
Hygroscopic moisture	2.312	7.456
Absorbed at	10° C.	

These analyses were made of soil from the Cajon Land Company's tract. The red soil was taken to 12 inches depth and the subsoil at a depth of 3 feet. In regard to these Prof. Hilgard says:

Chemically, the difference between soil and subsoil is but slight, so far as the supply of plant food is concerned. In potash they are nearly alike, and the supply ample; the phosphoric acid percentage is identical, and quite low, yet in the presence of a good supply of lime, especially in the subsoil, which is of such unusual depth, a deficiency in this respect will not be felt for some time to come by deep-rooted crops. Phosphates will doubtless, however, be the first fertilizers needed to be supplied when the time comes. As in nearly all upland soils of the southern region, the supply of vegetable matter is quite small, and should in cultivation be increased by every possible means. All the characters of this soil point to its preëminent adaptation to the cultivation of fruits, especially of those which, like the grape, can readily be so managed as to draw but lightly upon the phosphates and nitrogen of the soil, by a return of the pomace and other offal. High quality rather than exuberant quantity of product is foreshadowed by the soil characters; yet the experience had shows that, even in the latter respect, the Cajon lands are not behind, the great thriftiness of vine and tree growth being a matter of record; as is, also, the excellent quality of both raisins and wine already produced.

Analyses like the preceding are very valuable where soils have become impoverished, as they point out the treatment best adapted to fill the needs of particular soils for special crops, and show the excess of injurious elements or their absence. Yet, in cases of new and untried soils, an analysis showing an abundance of plant food may not harmonize with the growth of plants upon the same soil. This is due to the fact that plants are often unable to appropriate what the soil contains, owing to the existence of unfavorable chemical combinations. The most direct and also the surest way to test the adaptation of a soil to a given crop is by trying that crop upon it. The successful growth of vines in a given region or on a given soil is the surest test and the best evidence that the region and soil are adapted to the needs of the vine. There is no doubt that soils having successfully grown vines for twenty-five or fifty and in some cases for seventy-five years, with but slight attention to artificial fertilizing, are preëminently adapted for that purpose. This has been the case in several regions now denuded through the action of this disease. In the same regions, and often in adjoining fields, young vineyards two, three, four, five, or six years old have died as completely as the old vineyards, although more slowly. This is true where there is no reason for supposing the soil in the young vineyards to be less fertile than in the older vineyards when the vines were of the same age. At Anaheim, vines had produced well for a quarter of a century; still, young vines not five years old have died by hundreds of acres on lots adjoining these old vineyards. The same is true at Pomona, San Gabriel, Los Angeles, Capistrano, etc.

In some few places where vines are grown in southern California, there are evidences of an excessive amount of alkali. In the Cajon Valley, San Diego County, I saw a small spot in a vineyard where the vines were evidently injured by it. Where the soil is wet and alkaline the leaves of vines growing upon it are often of reduced size, much as where there is an impervious subsoil. This was very evident in the latter part of September, 1889, on the ranch of G. K. Porter, at San Fernando. The vines here, which were of the Mission and Muscat varieties, were situated on ground lying below an artesian well or spring. This, I believe, accounted for the strange appearance of their foliage. The leaves were very small, much striped, and somewhat curled, and entirely different in size and color from the normal leaf of the same variety. While these effects of alkali are occasionally met with, they are far from common in vineyards south of the San Bernardino range of mountains, and there is no reason to suppose that alkali has any bearing on the disease. One of the crops most readily showing the effects of alkali is corn. Where alkaline spots occur in fields of this cereal they are sharply defined in the reduced growth and enfeebled condition of the stalks. Corn has been grown with success throughout much of the diseased region, both before and since the death of the

vines. At Garden Grove, where the amount of surface and artesian water has injured many fields by bringing up the alkali, facts show that abundant corn crops have been produced on ground where vines previously died. This is also true at Norwalk. Mr. S. G. Baker, of that place, writes, under date of January 28, 1891, that he "grubbed out 35 acres of dead vines in the winter of 1889 and early part of 1890, and raised 40 bushels of corn per acre on the same ground."

CHAPTER VI.

INFLUENCE OF SHADE.

Shortly after beginning fieldwork in California I learned that there were some interesting phenomena connected with the effect of shade upon the development of the vine disease. My attention was first called to this fact by Mr. F. J. Kimball, of McPherson. He had observed the effects at two places, both of which were studied. On June 10 I visited the vineyard of Dr. S. S. Wood. It is situated about half a mile southwest of McPherson. On the south side of the vineyard, between it and the place of Mr. Ainsworth (mentioned on p. 108), was a long row of large pepper trees. These had very heavy tops and dense foliage, and probably averaged not less than 40 feet in height. The vines were of the Muscat variety, of medium age, and had been of thrifty growth. The first line of vines was set about 25 feet north of this heavy growth of trees. The vineyard extended along the line of trees for about 432 feet, the rows containing 54 vines, set about 8 feet apart. At the west end of the vineyard, where the sun could reach the vines from beyond the trees, the last 2 vines were dead in the first row on June 26, 1889. Throughout the remainder of this line all the vines were living except 2, and some had very fine tops, a few reaching up as high as a man's head. We have, then, in this row of 54 vines, 50 in comparatively good health, and of the 4 others 2 had evidently died through lack of shade at the end of the trees. The second, third, and fourth rows of vines were more or less broken, but a considerable percentage were still living and showing a good season's growth of cane. This may be seen by Plates X and XI. Only about one-half of the length of the south side of the vineyard can be seen in Plate X, but the comparatively healthy condition of the three or four rows of vines along this side may be distinctly made out. In the fifth row, which was beyond the reach of the shade, 40 vines out of the 54 in the row were entirely dead, while the remaining 14 yet alive showed only a small percentage of vitality. Most of them had only a few leaves on a stunted growth. In row one, the percentage of dead vines was 7.4; in row five it was 74. Beyond this row the vineyard was worthless, only a vine here and there having vitality enough left to produce a top as large as a bushel basket, and the greater part were dead. It is interesting to note that it was not the extra space of earth between the trees and vines which had saved the latter, for the exposed end vines had died, and the earth conditions

were there the same.[1] All conditions seemed to be favorable for a healthy growth of the vines. The cultivation had been of the best. The soil was good and was producing a good crop of corn between the vines in one part of the dying vineyard. Plate XI shows a portion of the line of trees throwing the shade, while Plate X represents the view from beneath the trees and looking into the vineyard. The shade at midday would extend much further into the vineyard than shown, and would include most of the living vines seen within the limits of the plate.

The H. Wilson place at Tustin had a little less than an acre of vines, along the south side of which ran a row of cypress trees. The trees averaged about 30 feet in height, were close together, and the first row of vines was within 20 feet of them. Two rows of Malvoisies were so well protected by the shade of these trees that they bore leaves and fruit a year longer than those exposed to the sun. They had been in bearing about five years in 1889. Four rows were said to be protected to some extent. One portion of the vineyard was removed a year earlier than that next to the trees.

About 3 miles northeast of Orange was formerly a vineyard at the side of an irrigating ditch, belonging to Mr. C. S. Smith. Along the side of this ditch young pepper trees were growing to a considerable height. They had not been pruned and the limbs hung down and the vines at the eastern edge of the vineyard were growing under them. I visited this place about the last of June. At that time the vineyard as a whole, was dead and gone, but the vines beneath the trees were still living and some of them had sent up a long growth into the trees. The vines in the most dense shade as a rule looked best.

On the place of G. O. Newman, Riverside, was a vineyard one-half of which was growing beneath an apricot orchard, while the other portion was unsheltered and lying to the south. At the date of my visit, August 19, 1889, the vines having the protection of the trees were of a normal green, with a good growth of cane and foliage and comparatively free from disease. The unprotected part of the vineyard was yellow with disease and contained many shrunken grapes, while the fruit beneath the trees was mostly plump. Mr. Newman thinks this condition of disease was due to sunburn. But in sunburn the leaves dry and curl; the drying is uneven and no regularity can be assigned to it. In the case of these vines the peculiar markings of the disease were well brought out in spots and stripes. It was also held by Mr. Newman that because these vines produced a good yield of fruit in 1889 that they must be healthy, but this is far from a necessary conclusion. This low, moist situation is, however, very favorable for their life.

On the south side of Mr. Langenberger's vineyard of Jacques vines,

[1] This feature of the subject is more fully considered in the record of the Scarritt vineyard beyond.

at Anaheim, are two large lemon trees, the shade of which falls upon three vines. These shaded vines showed, upon my visit, only a small amount of disease, while those next them, but exposed to the sun, had leaves badly yellowed with disease. The green of the shaded vines was several shades deeper than that of the others and the canes were ripening quite evenly, which is now very exceptional in the diseased region. For the appearance of the diseased leaves in this vineyard at the date when these observations were made see Plate XXI.

On the place of Mrs. J. Strodthoff, Anaheim, I noticed that there were some Isabella vines on the fence of a henyard. These vines had borne well, and they showed their former healthy condition by their size. At the time of my visit they were mostly dead. The only vine having any vitality worth mentioning was one running into a tree standing in the yard, which served to shade the vine through the heat of the season.

Mr. G. W. Ford, Santa Ana, had, in 1889, at the rear of his house, an arbor of twenty Isabella vines set in 1879. All the vines were dead when I saw them except one, which stood next to a hydrant. This vine bore a few grapes in 1889. It had been shaded in part by a tree growing near. The leading cause of the prolonged life of this vine was evidently, however, the frequent and moderate application of water from the hydrant. These vines were large and fine and had covered an arbor 30 feet long and 10 feet wide with a dense growth. They had always borne well before the appearance of the disease. The hydrant was within 3 feet of the living vine, and this had been cut back in the fall of 1888 to enable it to survive another season.

John Evans, of Fullerton, built a house in the spring of 1888 in a Muscat vineyard between Santa Ana and Tustin. The vines were planted in the spring of 1884. When the house was built the vines were not removed from the ground, and a number of them remained beneath the house. The vineyard was in good condition when the house was built. Upon my visit I found the vines nearly dead throughout the vineyard. But beneath the house, which was raised some 3 feet from the ground, the vines which had been covered by the building for two years were in quite a healthy condition. Some of the green leaves were uniform in color and of normal appearance with the exception of the usual effects of shade. The growth of cane was long, and in some cases quite uniform in color.

Southeast of Santa Ana was a vineyard of Malvoisie vines bordered along the south by a hedge of Monterey cypress. The vines near the trees were evidently in much better condition, so far as disease was concerned, than those beyond the reach of the shade. Seven rows of vines here appeared to feel the effects of the shade. As the ground is slightly lower toward the trees, however, this may possibly account for the number of rows of vines showing exceptional vigor. Mr. J. N. Smith, of Santa Ana, informed me that he had seen a vineyard protected along the south side by a row of trees, and that the first three

or four rows had lived, while those further from the trees had succumbed to the disease. Perhaps this place was the same as that above noticed by myself.

At San Fernando, Mr. C. R. Rinaldi said he had observed that vines were protected in some manner by shade from the action of the disease. At Florence and just north of the line of the great Nadeau vineyard is a hedge mostly composed of large pepper trees. North of this hedge is a vineyard. At the time of my visit the vines next the trees, and especially in the more protected spots, were resisting the disease much better than those exposed to the sun's rays.

On July 6, 1889, the vineyards between Los Angeles and Florence were visited. Upon that date an apparent exception to the protective power of shade was observed on the place of Mr. George Nadeau. On the north side of an east and west road is a line of blue gum trees (*Eucalyptus globulus*). The vines at the north and near the trees were Missions. They were scattered and stunted, while those in the field were quite uniformly thrifty and green. I could not account for this apparent reversal of former observations, and the matter remained as a stumbling block up to August 30 of the same year. In these two months the disease had worked marked changes in the vineyards in the Santa Ana Valley, and I was anxious to see the Nadeau vines after the hot weather. The entire matter was soon explained. It is well understood that the Eucalyptus will extend its roots to a great distance and will take up a great amount of moisture from the soil. The fact is very evident in places where corn has been planted near the trees. The height of corn stalks will often diminish from an 8 to 10 foot average in the field to 2 to 3 feet near the trees. The appearance first noted in the Nadeau vineyard was due to this action of the trees. The rows of vines near the trees had been stunted and some of them killed by the impoverishing and drying action of the Eucalypti, while the vines in the open vineyard had made a thrifty and even growth. At the date of the first visit these conditions were the ones most apparent. Upon the second visit I found the disease had been working, and while the growth of the vines next the trees was green and normal though upon stunted stocks, that of the more distant vines was yellowed, diseased, and rapidly dying.

In the vineyard of Mr. Nisson, north of Santa Ana, a row of walnut trees extended from east to west. On the north of this row of trees the Black Malvoisie vines came close under the trees. The second row of vines, which received the shade and not the direct effects of the roots of the trees in drawing moisture from the soil, were much more thrifty than the balance of the vineyard. It was evident the trees had protected this line of vines from much of the effects of the disease.

Mr. John Adams, of Anaheim, mentioned the effect of shade upon his own place (see at the southwest on the plat of Anaheim). On the south side of this vineyard was a dense hedge of cypress trees which also extended along a portion of the east side of the vines, thus making

a corner of quite dense shade. The vines were hardy Malvoisies. Those next the trees lived at least one year longer than the rest of the vineyard. The first row of vines was about 14 feet from the trees. In the corner and for some distance along the south side from the corner the vines lived best. A little distance from the corner and beyond the dense portion the hedge thinned out somewhat. Opposite this thin part the vines died out entirely and quite uniformly with those in the open vineyard. Still further from the corner, the hedge became thicker and the vines were there in good condition. This was the gentleman's own statement of the matter and independent of any suggestions of my own. To see how perfectly his observations accord with mine made on the Scarritt place, at Orange, I will refer to the diagrammatic record presented of the latter vineyard and the notes accompanying it.

On the place of Mr. Peter Ainsworth, at McPherson, a new vineyard was set in the spring of 1886 from Muscat cuttings. On the south side of this vineyard was a row of Monterey cypress, averaging about 25 feet in height. The row of vines nearest these trees was some 13 or 14 feet distant. During the summer of 1886 the vines made good growth, but in the fall, when they shed their leaves, there was evidence of disease; the wood had not the right color. The three rows of vines next the trees looked quite healthy in 1887, the row nearest the trees being most and the third row the least healthy of the three. All the others were badly diseased. Under ordinary conditions the rows of vines next the trees would be least thrifty. They would have a lighter growth and a smaller percentage of fruit, and this of inferior quality. There was no ditch or other water suply near these vines which could aid in maintaining them in more vigor than those in the open vineyard. Shade is the only apparent cause of difference. This record shows that the effects of shade are still produced, and are not an effect of some past exceptional time. Such an effect, for example, as might be produced in retarding the growth of vines during the hot days in winter of any past year.

It is thus seen that shade retards the work of the disease in many parts of the region affected, and that the shade of Eucalyptus, walnut, pepper, apricot, lemon, and cypress trees, or of buildings, produces the same effect. It is felt alike by old or young vines, and those of many varieties. Other records might be added to this list, but I will conclude the subject with the presentation of phenomena observed in the vineyard of Col. J. A. Scarritt, of Orange.

The vineyard is situated about half a mile east and a little south of the center of Orange. The vines were all of the Muscat variety, and set in 1881. The disease was first noticed in them by Mr. Condit, a former owner, about 1886, and at a distance of about five or six rows from the trees on the south side. No fruit was picked from about fifteen rows of vines, because it had failed to properly ripen. The gen-

tleman was unaware of the presence of the disease until he went to pick the grapes. The vineyard was irrigated but twice prior to the appearance of the disease, and had always been well cultivated and kept free from weeds.

By referring to Chart 1 the entire situation in this vineyard may be observed so far as shade is concerned. Along the south line is a row of Eucalyptus trees about 30 feet distant from the first row of vines. The comparative size of these trees is indicated by the size of the circles. The position of each tree is accurately shown. By the narrowness of the foliage line where no other trees are given it is seen that the perpendicular shade is not very great. The line of trees continues along the west side of the vineyard, where they still continue to be about 30 feet from the first row of vines. Running close inside the line of Eucalypti is an irrigation ditch from 6 to 8 feet wide and perhaps 3½ feet deep. This ditch contains water only during the "run."

Between the ditch and the vineyard is a line of walnut trees extending east and west parallel to the vines. This line of trees is variable in size, as indicated by the size of the circles and the foliage line. The distance of the walnuts from the first row of vines is 12 to 14 feet. Many of these trees had tops of considerable size, extending over the first and in some places over the second and third rows of vines. The vines were set about 8 feet apart each way, and each row from east to west had sixty-nine vines. From north to south only the first thirteen rows are included in the chart. The remainder of the vineyard was quite similar. The foliage line is shown on the chart by parallel, perpendicular lines. The shade cast by the trees at 8:30 a. m. on July 18, 1889, is shown by lines drawn diagonally from the left down toward the right; that cast by the same trees at 3:30 p. m. on June 15, 1889, is shown by lines from right down toward the left. The figures in the place of vines show the amount of vitality in each one on June 15. 1889, as indicated by the top. "1" would equal 10 per cent of vitality remaining; "2" equals 20 per cent, etc. A round, black spot shows the vine to be dead or nearly dead, having less than 10 per cent of vitality in it at the time of examination. I have calculated the amount of vitality shown from west to east (left to right) in each of the thirteen rows of vines, and the column at the right of the chart gives the results. They have been reduced to integral and decimal numbers, or whole and decimal equivalents of healthy vines. For instance, in the upper rows of sixty-nine vines the vitality remaining was equal to that in 5.3 perfectly healthy vines ; in the lower row of sixty-nine vines the shade has preserved the vitality so it is equal to that of 22.5 healthy vines. A careful examination of this equivalent column shows that in the first three rows of vines next the trees the vitality was equal to that of 43.9 healthy vines; while the remaining ten rows only possessed vitality equivalent to that of 37.8 healthy vines. The vitality in the first three shaded rows was equal to 6.1 healthy vines more than existed

in the next ten unshaded rows. We here see the striking difference in the various situations examined where there is shade in a diseased vineyard. Another phase of the matter which this chart explains requires consideration.

It might be said that the greater vitality in the vines next the trees is due to subirrigation from the irrigation ditch, or that these vines have a larger earth surface to draw nourishment from. These two phases of the matter have been considered, and the chart will serve to illustrate the conclusions. These conclusions have been drawn from many observations in various situations. In some the shade was present, but the irrigating ditches were absent; in some the trees and vines were set close together throughout the vineyard, so that little more earth surface could be had by the vine near the shade than in the open vineyard; some, where the trees were injuring and stunting the vine growth, showing that the food supply of the vine was less near the trees than beyond. In all these cases the effect of shade was to retard the work of the disease. The chart also shows the following facts in relation to shade, which plainly demonstrate that it was not subirrigation or increased land surface which saved the vines. Along the west of the vineyard (at the left) the shade only reached the vines during the afternoon. The equivalent vitality in the 13 vines of the first west row equals 2.3 healthy vines. Here the water and soil surface conditions were just the same as they were along the south and more shaded side of the vineyard. Now add the vitality equivalents for 13 vines in the first row along the south side of the vineyard, beginning at the right-hand shaded portion. The first 13 equal 5.4 healthy vines. The second 13 equal 5.6 healthy vines. The third equal 6.3 healthy vines. Omitting 7 vines where no shade existed and taking the following 13 vines, there is still an equivalent vitality of 3.5 healthy vines. The average vitality of these four lines of shaded vines is equivalent to 5.2 healthy vines, or more than twice as great as that seen in the first row at the west, which was only equivalent to 2.3 healthy vines, the water and earth conditions being alike in both cases. Omitting the water conditions and the effect of shade during a portion of the day, and comparing the unshaded vines at the east of the vineyard where there is the same margin of soil to draw from as in other cases, the vitality in 13 vines is only equivalent to 2 healthy vines, and 1.3 vitality is due to a little shade at the south of the row. Deducting this, there is left only 0.7 equivalent vitality in the remainder of the 13 vines, and this is to be compared with an average equivalent vitality of 5.2 seen in the shaded row of vines. The facts are equally well illustrated in the south row of vines. Here an increased vitality of the vine obviously depends upon the degree of shade in which it is grown, the few exceptions to this being no more than can be accounted for by proximity to shade and the normal variation in hardiness of individual vines, which may also be seen in the open vineyard. It is shown that near the west of the vineyard where no

shade existed the vines are wholly dead. Further to the right another break in the shade occurred, and here the vitality of the vines is greatly reduced. The water conditions, as far as the irrigating ditch is concerned, are the same, and even a greater amount of soil is granted the vine as the trees are missing.

Under temperature conditions reference will again be made to this chart. It will there be seen that soil temperatures correspond uniformly to the amount of vitality in the vines. The facts here given are sufficient to show that shade has a marked retarding influence upon the work of the disease, but, as the cause of the disease is not determined, the nature of this shade influence is still in doubt.

There appears to be no connection between the effects seen and protection from winds, as vines under a single row of trees, where there is little or no protection from winds, are preserved. It might be said that the vines were protected from some sudden change of temperature during some past winter, as is held by many, but the same preserving effects are noted upon vines grown beneath deciduous trees as upon those grown beneath evergreens. The main shade in the vineyard shown in the chart was derived from walnut trees, and where these trees were missing the vines died. The same was true in the Nisson vineyard, and in another south of Santa Ana. In both cases the protection was given by the apricots among which they were planted. The fact that vines but recently showing disease feel the effects of shade as much as those in a longer diseased condition indicates that the shade effects are present, and not past, especially where vines set since others have died show this influence. It is probable, then, that the influence of shade is one relating especially to conditions existing in summer. Or it may arise from the fact that vines grow more slowly in shade, and are in some way more hardy than vines grown in the light. Slow-growing pear trees blight less easily than rapidly growing ones. It seems probable that the effects of shade are beneficial to the vine in one of the following direct or indirect ways: (1) By inducing slower evaporation of moisture from the soil; (2) by inducing a slower transpiration from the leaves; (3) by retarding the development or effects of parasites requiring certain temperatures; (4) by a combination of these influences.

CHAPTER VII.

RELATIONS OF METEOROLOGICAL PHENOMENA.[1]

RAINFALL.

It was shown when considering irrigation that there was a marked and rapid development of disease within the years 1885 and 1886. It was also shown, under the head of increased fruitfulness of vines, that the year 1884 was one of wonderful yields in the vicinity of Anaheim. Overproduction immediately precedes the stage of disease observable to the eye, and it is very probable that it constitutes the first real symptom of a diseased state of the stock. From these facts and from the fact that some vines showed the disease in 1884, some of them dying the following winter, we may infer that 1884 was the first year of the virulent form of the disease resulting in the death of vines in 1886 and later. With these views before us it is desirable to consider climatic features to ascertain if any marked exception to the usual conditions occurred during the years from 1884 to 1886.

Under the head of rainfall will be given the amount of water which has fallen at several of the leading places in southern California. This will include observations made at Anaheim and at several other places in the affected region, Los Angeles, San Bernardino, and San Diego.

Tabulated rainfall records.—I have been unable to ascertain the water precipitation at Anahiem further back than the year 1877, but this is sufficient when records to a much earlier date are obtainable on all sides.

The following figures are from observations made by the Southern Pacific Railroad Company, and were supplied by J. E. Maxfield, second lieutenant, Signal Corps, San Francisco.

Rainfall at Anaheim, Orange County.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year.
1878....	2.19	4.07	1.49	1.93	0.52	none	none	none	none	0.15	none	0.95	11.30
1879....	1.36	0.57	0.35	0.37	none	none	none	none	none	0.28	3.90	3.93	10.76
1880....	2.39	1.57	1.77	9.74	1.12	none	none	none	none	0.28	0.44	4.92	22.23
1881....	1.25	0.28	0.85	0.06	none	none	none	none	none	0.81	0.34	0.37	3.96
1882....	0.30	1.90	2.42	0.48	0.40	none	none	none	none	0.26	0.78	none	6.54
1883....	1.48	1.98	1.22	0.10	2.78	none	none	none	none	1.12	none	1.40	10.08
1884....	2.80	10.58	6.70	1.75	0.54	1.28	none	none	none	0.15	0.64	3.72	28.16
1885....	0.61	none	none	0.64	none	none	none	none	none	(*)	2.93	1.16	5.34
1886....	4.63	0.82	2.70	2.15	none	none	none	none	none	none	0.33	none	10.63
1887....	0.43	5.71	none	2.21	(*)	none	none	none	(*)	0.75	0.92	2.16	12.18
1888....	6.29	0.92	5.90	(*)	none	none	(*)	none	none	(*)	3.75	4.19	21.05
1889....	0.14	1.28	0.24	7.97	0.57	none	none	(*)	0.76	2.31	0.30	10.95	24.52

* Trace of precipitation less than 0.01 of an inch.

[1] R. E. Kerkam, chief of the Pacific coast division, U. S. Weather Bureau, San Francisco, has kindly reviewed this chapter.

The following table runs from November 1, 1871, to December, 1887. The figures are from the annual reports of the Chief Signal Officer. They show the rainfall by calendar years; also the totals and averages by months:

Rainfall at San Diego, San Diego County.

Year.	Jan.	Feb.	Mar.	Apr.	May	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year.
1871	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.19	1.39	.....
1872	0.99	1.63	0.46	0.26	0.12	none	none	0.18	none	none	none	1.41	5.05
1873	0.34	4.15	0.11	0.10	0.01	none	none	1.95	none	none	0.77	5.46	12.89
1874	3.11	3.73	1.20	0.35	0.32	none	0.12	none	0.04	0.53	0.88	0.55	10.83
1875	2.38	0.37	0.45	0.12	0.20	0.02	none	0.21	0.39	none	2.25	0.41	6.80
1876	2.47	2.44	1.78	0.06	0.05	0.05	0.03	0.06	0.03	0.08	0.04	0.15	7.24
1877	1.05	0.23	1.44	0.26	0.43	none	none	none	none	0.81	0.06	3.89	8.17
1878	1.45	4.83	1.41	2.91	0.58	0.16	none	none	none	0.96	none	1.57	13.87
1879	3.54	1.04	0.10	0.60	sprin.	0.07	none	none	none	0.29	2.77	6.30	14.71
1880	0.61	1.50	1.43	1.34	0.06	0.06	0.09	0.32	none	0.53	0.28	4.15	10.37
1881	0.52	0.45	1.88	1.35	0.04	0.05	none	0.01	0.04	0.24	0.12	0.30	5.00
1882	4.53	2.55	1.02	0.45	0.18	0.07	none	none	0.01	0.41	0.39	0.13	9.74
1883	1.09	0.95	0.41	0.31	1.14	0.08	none	none	none	2.01	0.20	1.82	8.01
1884	1.34	9.05	6.23	2.84	2.17	0.31	none	none	0.07	none	0.11	4.83	26.95
1885	0.35	0.02	0.78	1.20	0.61	0.06	sprin.	0.13	sprin.	0.31	1.56	0.70	5.72
1886	7.00	1.50	3.73	1.95	0.04	0.07	sprin.	sprin.	none	0.05	0.95	0.10	15.39
1887	0.04	4.51	0.02	2.14	0.47	0.04	0.01	sprin.	sprin.	sprin.	2.08	1.14	10.72
Total.	30.81	38.95	22.45	16.24	6.42	1.04	0.25	2.86	0.58	6.22	13.65	34.30	171.46
Av'ge.	1.926	2.434	1.403	1.015	0.401	0.065	0.016	0.179	0.036	0.389	0.803	2.018	10.716

The following figures, from February, 1872, to June, 1877, are from the records of Mr. C. Duycommun, of Los Angeles; from July, 1877, to December, 1887, from Signal Office records:

Rainfall at Los Angeles, Los Angeles County.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year.
1872	.....	2.25	0.43	0.97	0.10	none	none	0.22	none	none	none	4.42	*8.39
1873	2.08	7.19	0.05	none	none	none	none	1.06	none	none	0.74	5.74	16.86
1874	5.51	9.77	1.09	0.45	0.42	none	none	none	0.06	1.81	1.89	0.20	21.20
1875	17.22	0.15	0.22	0.07	0.05	none	none	none	none	none	7.57	0.82	26.10
1876	6.54	7.92	3.41	0.45	0.03	none	none	none	none	0.40	none	none	18.75
1877	3.48	0.01	0.83	0.26	0.30	none	none	none	none	0.86	0.45	3.93	10.12
1878	3.33	7.68	2.57	1.71	0.66	0.07	none	none	none	0.14	none	4.70	20.86
1879	3.59	0.97	0.49	1.19	0.24	0.03	none	none	none	0.93	3.44	6.53	17.41
1880	1.33	1.56	1.45	5.06	0.04	none	sprin.	sprin.	none	0.14	0.67	8.40	18.65
1881	1.43	0.36	1.66	0.46	0.01	none	none	sprin.	sprin.	0.82	0.27	0.52	5.53
1882	1.01	2.66	2.66	1.83	0.63	sprin.	none	none	sprin.	0.05	1.82	0.08	10.74
1883	1.62	3.47	2.87	0.15	2.02	0.03	sprin.	none	none	1.42	none	2.56	14.14
1884	3.15	13.37	12.36	3.58	0.39	1.39	0.02	0.02	sprin.	0.39	1.07	4.65	40.39
1885	1.05	0.01	0.01	2.01	0.06	sprin.	sprin.	sprin.	0.05	0.30	5.55	1.65	10.69
1886	7.80	1.41	2.52	3.32	0.01	0.11	0.27	0.21	0.11	0.02	1.18	0.26	17.22
1887	0.20	9.25	0.29	2.36	0.20	0.07	0.07	sprin.	0.18	0.17	0.80	2.68	16.07
Total.	59.34	68.03	32.91	23.87	5.16	1.70	0.36	1.51	0.40	7.45	25.45	47.14	264.73
Av'ge.	3.956	4.252	2.057	1.492	0.322	0.106	0.022	0.094	0.025	0.466	1.591	2.946	17.649

* Total for eleven months.

The rainfall at San Bernardino is from records furnished by Mr. Sidney P. Waite, of the San Bernardino Water Company, and extends from July, 1870, to March 1, 1887, and is as follows:

Rainfall at San Bernardino, San Bernardino County.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year.
1870....	.....	.....	.....	.....	.....	.....	none	none	0.02	0.09	3.11	0.89	.....
1871....	6.91	2.21	0.19	0.34	0.11	0.07	none	0.04	0.13	0.60	0.88	3.91	15.39
1872....	none	2.20	0.37	0.79	0.06	none	none	0.18	0.04	none	1.17	4.40	9.21
1873....	6.50	1.25	0.51	0.84	0.21	none	none	1.06	0.02	0.01	0.74	5.73	16.87
1874....	5.51	8.76	1.08	0.48	0.42	none	none	none	0.06	1.82	1.88	2.20	23.21
1875....	7.20	0.15	0.22	0.07	0.05	none	none	none	none	none	7.50	0.02	15.21
1876....	6.55	1.92	3.41	0.44	0.03	0.03	none	none	none	0.20	0.40	none	12.98
1877....	3.50	4.03	0.83	0.26	0.30	none	none	none	none	0.86	0.50	3.95	14.23
1878....	3.33	6.68	2.57	1.71	0.66	0.07	0.07	none	0.02	0.14	0.05	4.70	20.00
1879....	3.59	1.00	0.50	1.20	0.24	0.03	0.11	0.02	0.01	0.94	3.40	6.50	17.54
1880....	1.56	1.33	1.45	5.00	0.04	none	none	none	none	0.14	0.67	8.80	18.99
1881....	1.40	0.36	1.66	0.46	0.01	none	none	none	none	0.80	0.27	0.50	5.46
1882....	*1.11	2.65	3.30	2.91	none	none	none	none	none	0.10	0.15	0.45	9.67
1883....	1.60	1.10	2.82	2.95	none	none	0.19	none	0.53	0.85	0.09	2.63	12.76
1884....	1.63	12.20	9.95	5.68	3.17	0.59	none	none	none	none	0.11	3.75	37.08
1885....	2.79	0.11	0.28	1.89	1.69	0.19	none	none	none	0.39	4.36	1.20	12.90
1886....	6.44	2.52	4.18	2.36	0.32	0.16	none	none	none	none	0.11	0.61	16.70
1887....	0.39	6.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.	60.01	54.91	33.32	27.38	7.31	1.14	0.37	1.30	0.83	6.94	25.39	50.24	258.20
Av'ge.	3.530	3.230	2.083	1.711	0.457	0.071	0.022	0.076	0.049	0.408	1.494	2.955	15.185

* Twelve inches snow January 12, 1882.

The following rainfall table of Santa Barbara was compiled by Mr. Hugh D. Vail, meteorological observer at that city. The table gives the total rainfall for each month and each year from January, 1868, to December, 1887; also the monthly and yearly averages.

Rainfall at Santa Barbara, Santa Barbara County.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for year.
1868....	3.97	2.00	1.08	2.44	0.72	none	none	none	none	none	1.25	4.26	15.72
1869....	3.26	2.12	4.22	0.46	0.20	none	none	none	none	0.30	0.65	0.57	11.78
1870....	0.25	5.87	0.83	0.99	0.74	0.07	none	none	none	1.04	0.27	1.41	11.47
1871....	0.86	2.92	0.02	2.02	0.37	none	none	none	none	0.09	1.83	6.56	14.67
1872....	2.53	1.81	0.18	1.80	none	0.14	none	0.02	0.05	none	none	4.34	10.87
1873....	0.58	5.48	0.05	none	none	none	none	none	none	none	0.27	5.26	11.64
1874....	4.54	3.17	0.78	0.28	0.14	none	none	none	none	1.91	1.30	none	12.12
1875....	14.84	0.18	0.38	0.10	none	none	none	none	none	none	6.53	0.31	22.34
1876....	7.56	5.67	2.73	0.27	none	none	none	none	none	0.32	none	none	16.55
1877....	2.72	none	0.82	0.18	0.45	none	none	none	none	none	1.32	3.12	8.61
1878....	7.17	11.73	2.47	3.34	0.29	0.07	none	none	none	0.35	none	5.16	30.58
1879....	5.24	0.71	0.34	1.60	0.21	none	none	none	none	0.41	1.62	4.57	14.70
1880....	1.30	10.86	1.15	5.73	none	none	none	none	none	0.25	0.28	9.73	29.30
1881....	2.83	0.30	1.25	0.59	none	none	none	none	0.44	1.47	0.33	0.95	8.16
1882....	1.13	2.38	5.74	1.63	none	0.20	none	none	none	0.37	0.77	0.10	12.32
1883....	2.18	2.92	3.64	0.29	2.79	0.35	none	none	none	1.32	none	2.76	16.25
1884....	6.33	9.68	9.77	2.60	0.39	1.62	none	none	none	1.02	0.79	6.62	38.82
1885....	1.23	0.07	0.35	3.00	none	none	none	none	none	0.19	9.84	2.47	17.15
1886....	5.12	1.19	2.03	3.40	none	none	none	none	none	0.39	0.87	0.86	13.86
1887....	0.31	8.64	0.13	1.43	0.33	0.03	none	none	0.38	0.31	1.10	4.43	17.09
Total.	73.95	77.70	37.96	32.15	6.63	2.47	none	0.02	0.87	9.74	29.02	63.48	344.00
Av'ge.	3.87	3.88	1.90	1.61	0.33	0.12	none	0.001	0.04	0.49	1.45	3.17	16.70

The above tables of rainfall have been extracted from the Annual Meteorological Review of California for 1887. The following table shows the seasonal rainfall for the vicinity of Santa Barbara, Los Angeles, San Bernardino, San Diego, and Anaheim. It covers periods of various lengths, according as it has been possible to obtain the desired facts.

Local seasonal rainfall.

Years.	Santa Barbara.	Los Angeles.	San Bernardino.	San Diego.	Anaheim.	Years.	Santa Barbara.	Los Angeles.	San Bernardino.	San Diego.	Anaheim.
1868–'69	15.77	.....	.....	.....	.....	1879–'80	25.64	20.34	20.36	14.36	24.70
1869–'70	10.27	.....	.....	.....	.....	1880–'81	15.23	13.13	13.50	9.66	8 08
1870–'71	8.91	.....	13.94	.....	.....	1881–'82	14.27	10.40	11.54	9.51	7.02
1871–'72	14.94	.....	8.98	6.04	.....	1882–'83	13.41	12.11	9.17	4.92	8.60
1872–'73	10.52	13.96	15.10	6.30	.....	1883–'84	34.47	38.22	37.51	25.97	26.17
1873–'74	14.44	24.78	23.81	16.89	.....	1884–'85	13.08	9.29	10.81	8.03	5.76
1874–'75	18.71	21.67	13.65	5.66	.....	1885–'86	24.24	22.72	21.93	16.99	14.39
1875–'76	23.07	26.74	19.90	10.11	.....	1886–'87	12.99	14.42	† 7.55	8.32	8.68
1876–'77	4.49	5.28	9.52	3.80	.....	1887–'88	.....	*3.90	.....	.....	16.94
1877–'78	29.51	21.26	20.33	16.10	12.72	1888–'89	.....	.....	.....	.....	18.14
1878–'79	13.61	11.35	11.54	7.88	3.75						

* To February, 1888.

† Total for season of 1886–'87, from July to March 1, 1887.

The following table will show the average precipitation at various points in southern California, mostly within the affected districts. The figures have been taken from tables contained in a report of the Chief Signal Officer on the rainfall of the Pacific slope, etc., Washington, 1888. Beside the average monthly and annual precipitation, the table shows what are the wet and dry seasons at the points given.

Local average precipitation.

Place.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year mean.
Anaheim[1]	1.81	2.75	1.74	1.48	0.54	0.13	none	trace	trace	0.34	0.93	1.90	12.12
Los Angeles[2]	3.93	3.76	1.90	1.34	0.35	0.09	trace	0.08	0.01	0.35	1.49	2.73	16.03
San Fernando[3]	2.31	3.79	2.27	2.00	0.43	none	0.02	trace	none	0.36	1.47	2.64	15.29
Colton[4]	1.36	2.36	1.42	1.55	0.57	0.08	none	0.02	none	0.25	0.50	1.20	9.31
Riverside[5]	1.12	1.97	1.93	1.16	0.43	0.12	none	0.60	0.02	0.27	0.37	1.38	9.37
Poway[6]	2.65	2.33	2.06	2.16	0.54	0.09	0.01	0.03	0.08	0.55	0.94	2.51	13.95
San Diego[7]	1.55	2.22	1.38	0.90	0.44	0.07	0.01	0.19	0.03	0.29	1.02	2.16	10.26

[1] 1877–1887, unbroken.
[2] 1871–1887, unbroken.
[3] 1877–1887, broken.
[4] 1876–1887, broken.
[5] 1880–1886, unbroken.
[6] 1878–1887, broken.
[7] 1850–1887, broken.

An attentive examination of these tables will show that the rainfall for the season of 1883–'84 was exceptionally great at all the leading points in southern California.

The seasonal rainfall at Anaheim for ten years, beginning September, 1877, exclusive of the season of 1883–'84, has an average of 11.12 inches. Beginning with the same year and including the season of 1883–'84, the

average for eleven years is 12.49 inches. The seasonal rainfall for 1883–'84 was 26.17 inches, or more than twice the average rainfall either exclusive or inclusive of this season for a period of ten or eleven seasons. The yearly rainfall at Anaheim for a period of ten years, from January, 1878, to December, 1888, excluding the year 1884, has an average of 11.4 inches, and for a period of eleven years from the same date and including the year 1884, an average of 12.93 inches. The yearly rainfall for 1884 was 28.16 inches, or more than twice the average precipitation for ten or eleven years either exclusive or inclusive of this exceptional year.

Comparisons with the preceding and following seasons show a still more striking contrast. The season of 1882–'83 had a rainfall of only 8.6 inches, the season of 1884–'85, 5.76 inches, while the intervening season of 1883–'84 gave the exceptional precipitation of 26.17 inches. This shows that at Anaheim there was a rainfall during 1883–'84 more than three times as great as that of the preceding year, and more than four and a half times as great as that of the following year. By comparing the yearly rainfall instead of the seasonal for these three years we arrive at nearly the same results. The precipitation for 1883 was 10.08 inches; that for 1885 was only 5.34, while that of 1884, the intervening year, was 28.16 inches, 2.8 times as great as that of the preceding year and 5.27 times as great as that of the following year. For obvious reasons the most valuable comparisons are those of the seasons. Before considering the possible bearing of this excessive rainfall upon the vine disease a brief review will be given of the facts showing the abnormal precipitation throughout the whole of this southern region.

The following table gives the average seasonal rainfall for 1877–'78 to 1886–'87, inclusive, including that of 1883–'84:

Town.	Seasonal average.	
	1877–'78 to 1886–'87.	1883–'84.
Anaheim	11.98	26.17
Los Angeles	17.32	38.22
San Bernardino	16.42	37.51
Santa Barbara	19.64	34.47
San Diego	12.17	25.97

This table shows that over the entire southern Californian region from Santa Barbara to San Diego the rainfall for 1883–'84 was at nearly every point more than 100 per cent greater than the average for a period of ten years. Comparing the average precipitation for the whole of southern California for the season of 1883–'84 with the average precipitation for the seasons of 1882–'83 and 1884–'85, we have the following striking contrast:

Average of rainfall at Los Angeles, Anaheim, Santa Barbara, San Bernardino, and San Diego:

1882–'83	9.64
1883–'84	32.46
1884–'85	9.39

These facts show a most wonderful variation in the amount of rainfall for these three years over this southern region. That two things are coincident in their occurrence does not prove that one bears any direct relation to the other. That the seasons of 1882–'83, 1883–'84 and 1884–'85 were exceptional seasons in the deficiency or superabundance of their rainfall in the region of the after development of the vine disease, is not proof of any direct relation between the two. The possibility of such a relation, however, is well worthy of careful consideration. That such exceptional conditions of rainfall existed immediately prior to the outbreak of the vine disease is not only a well-established fact but a very interesting and significant one.[1]

This variation of rainfall should be looked at from about the same standpoint as the subject of irrigation. But unlike the effect produced by irrigation, that resulting from the superabundance of rain was not local but as widespread as the disease itself. There are two ways to approach this subject: (1) Have these general variations of moisture directly induced weakness of the vine resulting in its death; or (2) have they induced an epidemic of animal or vegetable parasites bringing about the same result? In considering either of these subjects reliance is placed upon field notes.

DIRECT ACTION OF EXCEPTIONAL RAINFALL.

As vines have been successfully grown for eighty years and more in the district where they are now dead or dying we may start with the assumption that the normal rainfall of the region is incapable of producing the effects now seen. We must then look to exceptional conditions, and these must be prior to the summer of 1885, as extensive vineyards were known to be then failing, and later than the summer of 1882, as no diseased condition of the vineyards was then evident or suspected. The preceding tables show that these conditions really existed and, so far as time is concerned, in the proper relation of cause and effect.

There are, however, two facts which appear incompatible with the view that the exceptional rainfall of 1882–'83, 1883–'84, and 1884–'85 has acted directly upon the vines in a way to produce their death. The

[1] Mr. C. R. Orcutt, who has made a study of the plants of the southern region of California and of the Mexican peninsula, informs me that flowers were much more numerous in the spring of 1884 than usual. They also appeared earlier, and in sections where, on account of lack of moisture, they did not usually occur. The following is an extract from a letter written by Mr. Orcutt: "In the spring of 1884 not only was plant life remarkably abundant and luxuriant, but the insect world was equally prolific. There was an array of the larvæ of certain species of butterfly (I can not recall the species) known as cutworms, which were very destructive to flowers and plants, and would perhaps have cleaned the city [San Diego] out of green stuff but for the services of an equally abundant larva of a species of Calosoma * * * which preyed on the lepidopterous larvæ and other insects. An entomologist could have reaped a rich harvest that season."

first of these is that vineyards have died at later and later periods as we pass out from the vicinity of Anaheim. The second is that young vineyards, set each spring since these exceptional seasons, have contracted the disease and have died in the same manner as the older stocks.

The chapter on the extension or general development of the disease contains full demonstration of the first statement, and it may be further illustrated by the Mission vines belonging to Mr. T. H. Brigham near Florence. He had $2\frac{2}{3}$ acres which increased in productiveness up to 1888. For this vineyard the yields were, in 1886, 7 tons; 1887, $16\frac{2}{3}$ tons; 1888, 28 tons; 1889, 6 tons; 1890, nothing. These figures show that the disease did not kill the Mission vines at Florence until nearly four years later than they died at Anaheim, dying at the latter place in 1886 and at Florence in 1890. It is true this vineyard was not of the oldest. Had it been as old as the Anaheim vines it would probably have been entirely dead in 1889. An even more striking illustration of the same kind exists in the extensive vineyards southeast of Los Angeles, where many hundred acres of old Mission vines were still alive in 1889. These vines were four years later in dying than those of Anaheim. Mr. Charles A. Wetmore, writing of this disease in the Anaheim Gazette of October 30, 1886, says:

> It is said that the Mission variety has been most affected, yet within a few miles of Anaheim, even on the bottom lands near Los Angeles, where the surface soil is similar to that of Anaheim, this trouble was not noticed.

Mr. F. W. Morse,[1] reporting upon this disease to Prof. Hilgard in October, 1886, says:

> The chief trouble is in the immediate neighborhood of Anaheim, where the old Mission vines were first planted that have for many years borne large crops. Extending from this central point, or just south of the town, the damage gradually diminishes toward the vineyards of later planting. It is also found to a greater or less extent in the neighborhood of Orange and Santa Ana. It may be added that the trouble is not confined to these districts, as later observation has shown that vines of similar appearance may be found in other sections.

In regard to the Mission vines of San Bernardino County, Mr. John Hicks writes, under date of February 6, 1891, as follows:

> The year 1887 was the first I ever noticed of the vines being affected; very few of them had the grapes blasted, and some of those vines were entirely dead the next spring, and some started a growth and then died.

The vineyard referred to was nearly or quite as old as those of Anaheim, having been planted about 1860. The vines died after 1887 and were taken out in November, 1890. Prof. Paine's Mission vines east of Redlands bore as high as 6 or 7 tons of fruit per acre in 1888, when they were over 30 years old. This shows the disease appeared about four years later at Redlands than at Anaheim, and it is developing more slowly. The year of overproduction at and near Anaheim was 1884, and in this vicinity it was 1887 and 1888.

[1] Report of the Viticultural Work for 1885 and 1886. Sacramento, 1886, p. 176.

At Capistrano there were old Mission vines back of the town badly diseased, although covered with foliage in the summer of 1889. This shows a later development of the disease at the south as well as at the northwest and northeast of Anaheim.

If the general effects of the unusual precipitation for the winters of 1883 to 1885 were the direct cause of the death of the vines, would this account for the death of vineyards three and four years later at distant points? The vineyards which died later were in like soils, of the same variety and nearly or quite as old as the others. They had also been productive and apparently healthy while the others were dying. These facts alone throw grave doubt upon the theory that the above exceptional seasons were the sole and direct cause of the death of all the vineyards. The only explanation which seems to account even imperfectly for this discrepancy is that the disease has a much longer period of incubation at other points than at Anaheim. Allowing a considerable period of incubation in connection with a slow development of disease after becoming apparent, we may nearly approach the period necessary to explain the later death of the vines; but I do not think we are justified in this assumption.

The second reason why the rainfall has not been the direct cause of the death of the vines will be properly considered under the head of death of cuttings. It is sufficient to say here that there are a large number of facts showing that vineyards set out since 1885 have died with all the characteristic markings of foliage seen in the older diseased stocks. Several field records show that cuttings made in the winter of 1883–'84 and set out in the spring of 1884, after most of the rain had fallen, have died of the disease. How could the superabundance of water in the winter of 1883–'84 cause a cutting without roots or top and heeled in to die with inherent disease? Each winter, year after year, has been thus bridged over by cuttings, but they have died like the vines set prior to these exceptional seasons. Cuttings which have shown a previous healthy condition by taking root and forming a top have also died by the hundreds and thousands. Vines set as cuttings since these exceptional seasons (spring of 1887) and which grew well all through one season and up to the heat of the following year (1888) have succumbed. After vines have taken root and grown thriftily for an entire season and throughout all but the later months of the following season, how can it be said that the influence of rainfall occurring three years prior to their planting is the direct cause of their death? A large vineyard of Muscat vines was set near the foothills northeast of Tustin, on the place of Mr. George Irvine. The cuttings came from the northern part of the State and formed good roots and good tops the first season (1889). They showed such marked signs of disease before fall that Mr. Irvine plowed them out the same season or the following winter. There can be little doubt that these vines would have died of the disease under consideration had they been left.

INDIRECT ACTION OF EXCEPTIONAL RAINFALL.

In considering if the indirect action of the exceptional rainfall of 1882–'83, 1883–'84, and 1884–'85 has a bearing on the death of the vines, we see a considerable number of conditions which harmonize with this theory. Both the facts that vines have died at later dates the further we recede from Anaheim, and that they have died in the district of disease when set from cuttings in subsequent years agree with the idea. If the influence of these exceptional seasons or of the exceptional rainfall of the season of 1883–'84 was such as to produce an unusual development of some parasite, then the spread of this parasite from Anaheim as a center, where the vines were old and weak, would account for the results seen at distant places. The extensive death of the old Anaheim vineyards would supply the material for a renewed spread of disease for several successive seasons; and the slow death of the neighboring vineyards of more hardy varieties would retain the parasite in the region in sufficient abundance to account for the death of vines set subsequently. Whether such a parasite exists and what its action is if existing are matters to be considered elsewhere. The parasitic theory harmonizes with the observed workings of the disease. That the exceptional rainfall may have induced a fungous or other epidemic is not contradicted by the observed facts. It may be that local climatic influences besides rainfall have assisted in producing the described results. It may also be that the cause acting at Anaheim has also acted in a like manner, but to a less degree, throughout the entire region, producing local centers of infection at several places; but owing to the greater extent of old and weakened vineyards at Anaheim, general infection has spread from that point with more virulence than from any other place. This would not be incompatible with observed facts.

To conclude, it may be safely said that: (1) The rainfall, overabundant and deficient, occurring in the seasons of 1882–'83, 1883–'84, and 1884–'85 does not satisfy the requirements of the observed phenomena of this disease when considered as a sole and direct cause of the same; (2) this rainfall, if considered as a possible cause for the unusual increase of some parasite, may be indirectly responsible for the disease, conflicting with few, if any, of its observed phenomena.

FOGS.

The bearing of fogs on the disease is probably mainly indirect. They have been noted as one of the features of the coast climate for more than a century, and have probably always existed. During this time vines of the most susceptible Mission variety have lived and prospered in the region where they are now entirely dead. If fogs have had any direct influence the question would arise why their effect had suddenly changed within the last few seasons so radically as to leave not a healthy vine in many thousands of acres of vines previously perfectly healthy. If the action is direct there appears no good reason why vineyards in the coast region further north should now be healthy.

If this effect has been indirect it may be assumed that the fogs favored the development or spread of some recently introduced parasite. It is probable that April or May fogs do assist fungous parasites in this way. No evidence has been discovered that sea fogs are different at this time from what they have been in the past. Land fogs or atmospheric humidity would have much the same effect as rainfall.

TEMPERATURE.

The relation of temperature to this disease is important. From the first appearance of the malady in California many careful thinkers have considered heat and cold, or their combined effects, as the direct cause of the death of the vines. That peculiar temperature conditions have an essential influence on the disease no one familiar with it will be apt to question. Their exact bearing, however, will remain in doubt until the cause of the death of the vines has been ascertained.

TABULATED TEMPERATURE RECORDS.

Through the kindness of J. E. Maxfield, second lieutenant, Signal Corps, San Francisco, the following temperature records kept at Anaheim by the agents of the Southern Pacific Railroad Company between the years 1877 and 1889 have been obtained:

Temperature at Anaheim, Cal., from October, 1877, to June, 1889.

Year.	January.			February.			March.			April.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1877												
1878	80	40	50.2	74	42	55.8	82	48	58.6	83	50	61.6
1879	74	34	53.1	84	38	56.9	104	50	62.8	94	52	65.4
1880	78	32	53.2	72	32	51.4	80	33	54.2	80	48	59.9
1881	72	36	53.9	89	36	58.7	88	38	58.2	91	50	64.6
1882	75	34	51.4	75	34	52.1	86	40	57.7	80	52	61.2
1883	80	36	50.5	84	26	60.9	90	52	66.2	96	50	63.3
1884	72	42	57.0	89	40	60.4	90	36	63.3	80	50	65.0
1885	74	36	54.1	78	40	59.3	90	42	68.0	86	51	68.3
1886	74	34	57.6	72	42	57.3	74	42	58.5	74	48	61.2
1887	74	34	54.0	80	36	53.3	85	45	58.9	85	44	61.0
1888	78	34	55.6	77	48	58.5	74	44	59.5	92	52	66.9
1889	74	34	57.8	80	36	61.3	94	54	65.5	80	44	58.8

Year.	May.			June.			July.			August.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1877												
1878	88	58	66.8	86	62	78.4	96	62	74.2	94	64	74.5
1879	105	60	69.4	108	60	72.4	93	60	74.0	98	64	76.1
1880	96	55	67.6	90	60	68.8	88	58	70.2	98	60	72.2
1881	92	54	62.6	88	56	58.9	96	60	74.4	100	60	74.8
1882	88	54	69.9	82	62	69.2	90	64	72.3	96	62	75.4
1883	102	50	67.1	100	62	75.8	94	46	74.3	102	62	75.9
1884	92	54	69.2	90	54	71.5	92	62	74.2	96	60	75.4
1885	80	60	68.0	96	62	72.6	90	64	73.9	101	56	75.9
1886	84	56	66.4	89	60	69.1	98	58	72.3	94	63	76.6
1887	92	50	63.4	98	50	65.8	94	58	72.3	95	60	71.2
1888	88	58	67.9	87	60	73.5	93	62	71.3	86	62	72.1
1889	94	50	67.8	86	60	69.4						

Temperature at Anaheim, Cal., from October, 1877, to June, 1889—Continued.

Year.	September.			October.			November.			December.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1877	.....	.....	.....	78	46	60.7	90	44	62.6	83	39	58.4
1878	108	57	72.2	100	42	69.0	84	38	62.0	90	34	58.0
1879	103	58	72.6	97	50	67.9	84	44	58.4	80	34	53.8
1880	94	56	69.3	92	50	66.1	87	42	58.4	86	38	56.7
1881	102	56	72.4	86	44	64.1	83	38	59.5	84	32	56.2
1882	103	58	73.5	88	50	67.4	78	42	62.1	92	40	63.8
1883	107	60	77.7	86	48	67.3	86	44	62.0	82	48	51.9
1884	96	50	69.0	100	48	68.5	87	40	58.9	70	36	56.1
1885	106	56	72.8	88	48	66.9	84	44	62.7	86	40	58.9
1886	88	57	71.5	97	46	66.1	86	39	60.5	82	40	56.9
1887	94	60	71.7	94	54	70.6	90	40	61.5	72	40	53.8
1888	94	59	74.8	86	59	69.3	76	52	63.4	76	44	60.9
1889	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

The following table is from records kept at Los Angeles by George F. Franklin, of the United States Signal Office, and covers the period from July, 1877, to December, 1888, inclusive:

Highest, lowest, and mean temperature for each month and monthly averages for the period.

Year.	January.			February.			March.			April.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1877	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1878	72.0	37.0	54.9	71.0	41.0	55.0	76.0	41.0	56.0	80.0	41.5	57.8
1879	73.7	36.0	52.2	80.0	38.6	55.5	99.0	42.5	58.5	88.5	42.2	58.7
1880	76.0	30.0	51.3	70.5	33.5	50.1	73.5	36.0	51.1	83.0	40.0	55.9
1881	71.0	37.0	51.7	86.0	42.5	57.9	89.0	37.0	55.8	64.0	48.0	61.4
1882	74.2	32.0	49.4	76.7	32.0	50.3	87.8	35.3	55.3	80.0	40.2	56.4
1883	82.0	30.0	53.5	82.0	28.0	52.3	84.0	42.6	56.7	89.0	39.0	57.3
1884	78.0	33.7	53.9	81.0	38.5	55.1	72.5	37.0	54.8	80.0	41.5	57.2
1885	71.6	38.0	53.9	81.0	36.3	56.6	85.1	42.3	60.6	88.6	44.8	61.9
1886	75.3	32 0	54.7	81.0	41.1	59.5	76.0	37.2	54.3	80.0	42.3	57.2
1887	79.6	33.1	55.4	81.5	35.4	51.6	85.0	41.1	59.1	87.0	40.3	59.1
1888	71.0	30.9	50.0	73.5	39.2	54.4	79.0	35.9	55.1	99.0	44.0	61.9
Averages..	74.9	33.7	52.8	78.6	36.9	54.4	82.4	38.9	56.1	86.3	42.1	58.6

Year	May.			June.			July.			August.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1877	.....	.....	.....	.....	.....	.....	93.0	55.0	71.1	87.0	56.0	70.0
1878	89.0	47.0	62.2	81.0	47.0	55.0	88.0	52.0	67.7	89.0	54.0	68.7
1879	97.0	43.0	61.0	103.5	50.5	65.8	84.5	52.0	66.8	97.5	53.0	69.5
1880	97.0	42.0	61.1	83.0	50.0	63.4	85.0	52.0	64.2	87.0	52.0	66.4
1881	89.3	41.0	62.7	88.0	48.0	65.6	96.1	52.1	68.8	99.8	52.1	69.4
1882	86.1	42.1	61.7	87.1	49.6	64.4	98.1	52.3	68.0	98.9	57.0	71.0
1883	100.0	39.5	62.1	100.0	52.0	68.8	90.0	52.5	69.8	98.0	50.0	69.8
1884	79.0	47.0	61.6	98.0	49.5	65.6	99.0	51.5	70.2	101.5	52.5	71.3
1885	80.0	48.6	63.5	90.1	47.0	65.0	98.5	52.4	70.0	105.6	51.2	72.7
1886	89.0	44.2	62.4	91.6	48.2	66.1	98.1	50.4	69.7	98.1	53.7	71.8
1887	92.0	44.5	63.1	100.1	46.7	66.1	98.1	51.1	69.5	93.6	52.1	68.5
1888	83.0	45.0	60.8	94.0	50.5	67.5	95.0	49.0	67.9	97.0	51.3	67.6
Averages..	89.2	44.0	62.0	92.4	49.0	65.8	93.6	51.9	68.6	96.6	53.2	69.7

Highest, lowest, and mean temperature for each month, etc.—Continued.

Year.	September.			October.			November.			December.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
1877	93.0	52.0	69.6	80.0	43.0	63.4	86.0	45.0	62.1	81.0	36.5	56.0
1878	103.0	50.0	65.6	91.0	43.0	63.1	81.0	37.0	58.3	88.2	30.0	54.4
1879	101.0	47.0	67.2	96.5	42.5	64.3	84.5	36.5	55.2	76.0	30.0	51.9
1880	91.0	44.0	64.5	89.0	44.0	62.0	85.0	35.0	55.5	80.0	38.0	55.6
1881	102.0	50.0	67.9	82.3	43.0	60.9	80.8	34.2	57.5	79.3	35.3	54.7
1882	100.0	46.0	67.6	88.0	44.0	63.0	81.0	36.0	57.3	82.0	35.0	56.4
1883	103.5	53.0	71.9	83.0	43.5	61.0	84.0	42.0	59.2	80.0	37.0	56.3
1884	92.5	45.5	65.5	89.1	42.9	62.3	88.0	38.7	59.6	75.6	35.5	52.3
1885	108.5	51.2	69.5	102.3	41.6	64.8	78.5	40.3	59.5	82.0	40.3	57.9
1886	91.3	48.3	65.6	82.2	41.1	59.3	84.9	34.1	56.6	84.8	37.3	55.7
1887	91.0	49.2	68.2	93.2	47.2	65.0	86.0	38.8	60.0	73.2	35.2	53.7
1888	98.2	55.0	68.4	98.0	44.0	61.9	83.8	40.0	57.2	78.8	41.0	55.2
Averages ..	98.6	49.3	67.6	89.6	43.3	62.6	83.6	38.1	58.2	80.1	35.9	55.0

It seems unnecessary to give temperature records for other points in southern California, as Anaheim and Los Angeles are two centers around which the disease has been especially developed. A study of the temperature variations of these two places should reveal any exceptional conditions, if they exist, which have caused the death of the vines.

The temperature and humidity conditions existing in the season, extending from September, 1885, to August, 1886, have been assigned as the cause of the widespread death of the vines. Mr. Morse, in his report on this disease,[1] has undertaken to show that this season was such an exceptional one that it had this effect.

In making up the mean temperatures for the month, Mr. Morse did not divide the three daily records by three and then the sum of these daily averages by the number of days in the month; nor did he divide the sum of the mean maximum and mean minimum temperatures by two. But he obtained a monthly mean temperature by dividing the sum of the extremes of temperature of the month by two, giving a mean equidistant from the two extremes. Mr. Morse considers this mean temperature is of special importance, but in reality it does not show the facts in the case; and even if it did, not enough years are included to warrant the conclusions which are drawn. Figures of this kind, if they are of value, must show one of two things (1) The relation of the temperature of the month as a whole (mean temperature); or, (2) the relation of the extremes of temperature (range). The following will show where a mean between two extremes is lacking in the first requirement.

If the daily mean temperature for a week is, Monday, 100°; Tuesday, 20°; Wednesday, 20°; Thursday, 20°; Friday, 20°; Saturday, 20°; Sunday, 20°; the mean temperature for the week will be 31.4°, while the mean between the two extremes will be 60°. Now, if the temperature of all the days except Monday and Sunday be changed to 90°, the

[1]Report of the Viticultural Work of the College of Agriculture, University of California, for the years of 1885 and 1886. By E. W. Hilgard, pp. 176–184.

true mean will change to 81.4°, but the mean between the true extremes will remain the same. Although an extreme case this illustrates that a mean temperature obtained as Mr. Morse has obtained it, will not, except by chance, show the true temperature relations for the given time. For the month of September, 1885, the true mean temperature was 72.8°, while the mean given for that month by Mr. Morse was 82°, an error of 9.2°.

Another illustration will show that this method is of no value in representing range.

Maximum.	Minimum.	Mean.	Range.
°	°	°	°
70	50	60	20
80	40	60	40
90	30	60	60
100	20	60	80

I have not found any marked exception in this season, either of rainfall or temperature, to which any such wholesale death of vines could properly be assigned, after considering all influencing conditions. For the purpose of presenting the results of the studies of the temperatures at Anaheim the following table of comparisons has been prepared. It plainly illustrates the relation of the temperature for the seasons of 1885–'86, 1884–'85, and 1883–'84, to that for a series of eleven or twelve years, which is the extent of the records I have been able to obtain.

Comparative table of temperature at Anaheim, Cal.

Months.	Mean temperature.				Maximum temperature.					Minimum temperature.				
	1883–'84.	1884–'85.	1885–'86.	October, 1877, to June, 1889.[1]	1883–'84.	1884–'85.	1885–'86.	During period October, 1877, to June, 1889.	Extreme average, October, 1877, to June, 1889.[2]	1883–'84.	1884–'85.	1885–'86.	During period October, 1877, to June, 1889.	Extreme average, October, 1877, to June, 1889.[3]
September..	77.7	69	72.8	72.5	107	96	106	108	99.5	60	[4]50	56	[4]50	57
October.....	67.3	68.5	66.9	66.9	86	[5]100	88	[5]100	91	48	48	48	42	48.7
November ..	62	58.9	62.7	61	86	87	84	90	84.5	44	40	44	38	42.2
December ..	51.9	56.1	58.9	57.1	82	70	86	92	81.9	48	36	40	32	38.7
January	57	54.1	57	54	72	74	74	80	75.4	42	36	34	32	35.5
February ...	60.4	59.3	57.3	57.1	[6]89	78	72	[6]89	79.5	40	40	42	26	37.5
March.....	63.3	68	58.5	60.9	90	90	74	104	86.4	36	42	42	33	43.6
April.....	65	68.3	61.2	63.1	80	86	74	96	85	50	51	48	44	49.2
May.....	69.2	68	66.4	67.1	92	80	84	105	91.7	54	60	56	50	54.9
June.....	71.5	72.6	69.1	70.4	90	96	89	108	91.6	54	62	60	50	59
July.....	74.2	73.9	72.3	73	92	90	[7]98	98	93	62	64	58	46	59.4
August.....	75.4	75.9	76.6	74.5	96	101	94	102	96.3	60	[8]56	63	[8]56	61.1

[1] Obtained by adding the mean temperature of each month of each year separately and dividing by the number of years considered.

[2] The period mean of monthly highest temperatures, not the mean of the mean maximum.

[3] The period mean of monthly lowest temperatures, not the mean of the mean minimum.

[4] The lowest temperature of this month during the period compared; 1880, 1881, and 1885 range as low as 56° in September.

[5] In 1878 and 1884.

[6] 89° was reached in the year 1881 as well as in 1884.

[7] In both cases 98° refers to the extreme reached in July, 1886; 96° was reached in 1878 and 1881, and 94° was reached in 1883 and 1887; 93° was reached in 1879 and 1888.

[8] The lowest temperature for August for the period compared; 1880, 1881, 1884, and 1887 gave a temperature as low as 60° in August.

An examination of the preceding table shows that instead of the months of September, October, November, and December of 1885 being exceptionally warm, as has been claimed, September averages 0.3° higher than the period average; October was no warmer than the average; November 1.7° and December but 1.8° above the average. January, 1886, averaged 3° higher than the average for the period; February 0.2° above; March 2.4°, below; April 1.9° below; May 0.7° below; June 1.3° below; July 0.7° below, and August rose to 2.1° above. These figures serve to show that there was no variation in the mean temperature of the months of this season sufficient to kill thousands of acres of vines in all situations. On the contrary the mean temperature for the season was remarkably near the general average for the last eleven or twelve years. It may be said that the mean temperature of a given month is not that most likely to show exceptional and injurious changes. For this reason the table also contains the maximum and minimum temperatures for the season of 1885–'86 and for the period between October, 1877, and June, 1889.

By comparing the maximum columns it will be seen that in no month during the season of 1885–'86, with the exception of July, did the temperature rise as high as it did in some other year between 1877 and 1889. It may also be seen by referring to the table of temperatures at Anaheim from 1877 to 1889 that 96° was reached in 1878 and 1881, and that 98° in July, 1886, was no marked exception. A comparison of the two minimum columns, one for the season of 1885–'86 and the other the minimum between 1877 and 1889 shows that during no month of the year did the temperature run as low as it did during the same month in some other year between the two dates last mentioned. This shows that the year was not exceptional in maximum or minimum temperature, and it has already been shown that the mean temperatures present no marked exception. To complete these comparisons I have given for each month the means of the extreme temperatures for the entire period between October, 1877, and June, 1889. By comparing the maximum and minimum degrees of each month of the season of 1885–'86 with these average maximum and average minimum temperatures it will be seen that this season is well within the average and in no sense exceptional.

As shown in this table, September, 1884, had a mean temperature slightly below the average for the period. The minimum was 50°. Although this was the lowest temperature for that month the years 1880, 1881, and 1885 had a minimum temperature of 56°; and it is certainly not low enough to require further remark. The mean for October was close to the period mean, being 1.6° above; the minimum was only the mean minimum of the period; the maximum was high, but did not exceed that of October, 1878. November was not remarkable for mean, maximum, or minimum temperature. The same is true for December, 1884, and for January and February, 1885. The mean temperature of

March and April the latter year was above that of the period tabulated; but the maximum and minimum temperatures of these months were well within the limits of the period, and close to or within the mean maximum and mean minimum temperatures. For the months of May, June, July, and August there was nothing worth noting. The mean, maximum, and minimum temperatures were in no case extreme. The entire season seems to present few or no exceptions of importance. The high mean temperature of March, 1885, is noticeable; but when it is seen that five years out of twelve give a maximum March temperature as high or higher than that touched during that month, and that six years out of the twelve had a minimum March temperature as low or lower than that of March, 1885, it is evident that no serious results arose from this early opening of spring.

September, 1883, as the table shows, was quite a warm month. This was due rather to a high minimum than to a high maximum temperature. The maximum reached during the month was also high, being 107°. In 1878 a maximum of 108° was reached; and during the period of eleven years the maximum temperature was over 100° for six years out of the eleven. The mean maximum temperature for the eleven years was 99.5°. October and November, 1883, were slightly warmer than the period mean, while December was, as a whole, considerably colder. Here again, although the month was cool, no great extremes of temperature were reached. The maximum was but one-tenth degree higher than the mean maximum for eleven years, while the minimum was far above the average minimum for the same time. The range of temperature during this month was only 34°, and even had this change occurred suddenly, the temperature falling from 82° to 48° in a brief period, it seems wholly improbable that it would have killed a single grapevine, to say nothing of those on thousands of acres. Every month from January to August, 1884, had a mean temperature somewhat higher than the mean for the corresponding month of the series of years tabulated. The maximum and minimum temperatures for January, 1884, were moderate. In February, however, the temperature rose to a maximum of 89°, or 9.5° higher than the mean maximum for the period, and during the month the minimum was only 40°. The maximum reached in February, 1881, as in 1884, was 89°; but conditions of rainfall in the latter year were different. Although the winter after January, 1884, was warm, it was not so warm as in 1885, and taken alone it does not seem that it could bear any direct relation to the disease. Considered as having an indirect bearing in connection with excessive rainfall, its possible relation is less certain.

SEASONAL TEMPERATURE RELATIONS.

Nearly from the first it was noticed that during the spring months the growth of the vine was often so healthy in appearance as to induce the belief that the disease was passing off and the vines were recover-

ing. A letter from Mr. Benjamin Pratt to Prof. F. L. Scribner, dated September 22, 1888, gives an account of this. He says:

> Presuming you may have some interest in a report of the condition and prospects of the vineyards in this section, I write to inform you thereof. In the spring the vines started with a vigor quite different from that of the year previous. Many vines, dead above ground, threw up from the roots, or from the main stock below ground, apparently a healthy and vigorous cane. Every one felt encouraged at the apparent prospect, and concluded that the worst was over, and that vines not already dead or badly affected would recover their health and usefulness. They set but a light crop of grapes, which led me to conclude that nature intended the strength of the vine to be appropriated in repairing damages rather than producing fruit. I dug out 2½ acres of the worst affected of my vines; many dug up their entire vineyard. I began to regret digging them up when the vines showed such good prospects of recovery. Both my faith in recovery and my regret at having sacrificed a part of the vines were not of long duration. Before midsummer the vines began to show that same appearance of leaf, the same failure to mature the grapes set, and the same dying of the new growth of canes that you saw when here, only more extensively. The vines on what is called the "gravel land" in many parts of the valley are nearly dead, and from the present appearance I think but a small per cent of the vineyards in the valley will be worth saving after this year.

In its later stages the first leaves of spring often show the effects of the disease. But in young vines, recently diseased vines, and those of special varieties the effects of the disease are reduced to a minimum during the cooler portions of the year. This is especially true in the spring before the vine has felt the effects of the heat. The effect of springtime upon the vine is perhaps comparable to that produced by shade, which has been already treated of. During the fall months, after the heat has become reduced, there is also an apparent arrest in the progress of disease, although the canes left bare in midsummer continue to die and the injured leaves to fall prematurely. The spotted leaves remaining attached to the cane gives the stock a badly diseased appearance, even after the progress of the disease has seemingly been retarded. The moisture of the soil is greater in the spring and fall than during the heat of summer, and this fact as well as the cooler atmosphere undoubtedly has an influence on the vine. In many cases the disease develops rapidly soon after the heat of the season begins, or from the 15th of July onward. Nearly everyone has noticed this who has had experience with the disease. On newly set vines from healthy cuttings there is a cane growth and root formation of considerable extent during the early part of the growing season. Near Orange the vines in a vineyard not two years old, containing some 10 acres of Muscat vines, grew 4 or 5 feet in the early part of the season of 1889. This healthful appearance continued till the very warm weather of the season began, after which the spots due to disease became apparent. Before fall a large percentage of these vines lost their leaves and the canes turned black and died. A large part of this vineyard is now dead. Observations of this kind are too numerous and common

to require repetition. Beyond question the disease develops during the heat of the season.

On young, healthy vines or those recently diseased the spotting of the leaves appears to show first in the month of June. On badly diseased vines the disease usually shows itself in the spring by a stunted and backward growth. In July and August the progress of the disease is marked; but September is often the month when the most evident effects are seen, and this is also the month when the leaves begin to fall. After the rains and lowered temperature of October and November the bared green canes are seen drying and dying from the end. In many cases only one-third to one-half of the cane becomes properly ripened. During the winter months there is no marked change apparent except the continued blackening of the canes.

TEMPERATURE OF THE SOIL.

It has been quite generally observed, although not without exceptions, that in the slightly elevated places in a vineyard the disease first developed to a visible degree. This is due unquestionably to several reasons, which vary in importance according to special conditions in each individual case. The leading reason apparently is that the elevated spots are generally of a higher temperature than the surrounding soil. Heat of the soil as well as heat of the atmosphere seems to have a bearing on the disease. This is shown not only in the warmer soils of a special vineyard but in the affected region as a whole. In elevated localities near the foothills vines have perished earlier than on river bottoms and other cooler places, when conditions of age, variety, distance from center of infection, etc., were the same. Perhaps no better guide can be followed in examining this matter than the dates at which the grapes become ripe in the different places. For example, about the foothills east of Orange and Tustin the fruit ripens ten days or two weeks earlier than that of the same variety at Norwalk. The vines of these two sections also varied greatly in the times of their death. Many at McPherson and Tustin died in 1887, while at Norwalk vines of the same variety and age lived two years longer. Again, the grapes at the foothills in the above places were much earlier in ripening than those near the Santa Ana River, and the vines died much earlier in the former than in the latter place. Much of this variation is due to the difference of the soil in the two places, but temperature tests prove that there is a direct relation between the heat of the soil and the early or late death of the vines. On the vineyard plat (Chart I) are shown the places where soil temperature was taken in the vineyard of Col. Scarritt, of Orange, and the results are brought together in the following table. The letters A, B, C, etc., refer to the similar letters on the chart. The left-hand column gives the hour and minute when each registration was made.

Soil temperature in the vineyard of Col. Scarritt, Orange, Cal., taken July 18, 1889.

Hour of observation.	Location of test as per shade chart.	Surface temperature.	Temperature at depth of 18 inches.
		Degrees.	*Degrees.*
11:00 a. m.	A	84	70
11:20 a. m.	B	103	84
11:41 a. m.	C	[1]124	90
12:13 p. m.	D	114–116	90
12:40 p. m.	E	116	84
12:55 p. m.	F	84	73
1:13 p. m.	G	110	82
1:38 p. m.	H	111	82
2:05 p. m.	I	[2]114	85
2:40 p. m.	J	84	68
3:00 p. m.	K	110	82

[1] With earth touching the bulb of the thermometer 128° was reached. The temperature appeared to be extreme at the time this test was made, for at a distance of 8 feet to the right (east), but still in the sun, the surface temperature was 114° to 116° thirty minutes later.

[2] Temperature ranged from 107° to 114° at this point.

A comparison of this table with the shade chart brings out the relations between the temperature of the soil and the time of the death of the vines, as the latter is indicated by the amount of vitality in the vines when examined.

At A, F, and J, where dense shade existed, the surface temperatures were exactly the same, 84°, and the temperatures at 18 inches[1] below the surface were 70°, 73°, and 68°, respectively. Taking ten vines next each of these points it will be seen that the vitality remaining in the 30 vines is equivalent to that of 8.9 healthy vines. At G and H, where the ground was shaded during the earlier and later parts of the day, the surface temperature was 110° and 111°, respectively, and the temperature 18 inches below the surface was 82°, but the effect of the temperature here is not so marked. The vines are so near a dense shade that their roots feel its effects. At B, E, I, and K there was no shade during the day, up to the time of record, and the surface temperature was 103°, 116°, 114°, and 110°, respectively. The temperature 18 inches below was 84°, 84° 85°, and 82°, in the order given. The total vitality of 40 vines, counting the 10 nearest each of the points under consideration, only equals that of 3.4 healthy vines. At C and D the surface temperature is 124°, and 114° to 116°, while the temperature 18 inches below is 90° in each case. No shade fell at either place at any hour of the day, and trees on two sides confined the heat. At C the vitality in the 10 nearest vines only equals that of 0.2 healthy vines. At D every one of the 10 nearest vines is wholly dead.

[1] The method adopted to obtain these temperatures was simple, but sufficiently accurate for the purpose. A metallic tube was made of the desired length and large enough to admit of the thermometer being passed through it. This tube was rapidly set in the ground to its full length and the thermometer taken from the shade and lowered to the cool soil at the bottom. The tube was then tightly covered and left ten minutes, or until the mercury of the instrument ceased to change. A reading was then taken and the degree and time of day recorded. Where any doubt of the reliability of the test existed a proof test was made.

In a small vineyard belonging to Mr. S. F. Clark, northeast of Orange, the northeast corner was higher than the rest. Over this elevated portion the vines died one year earlier than upon the lower ground. On July 24, 1889, I took the temperature of the soil in three places, 18 inches below the surface, one upon the elevated portion and two upon the lower parts of the vineyard. On the elevated portion the temperature was 85°+, and on the lower 81° — and 81°+.

On the place of Mr. Fred Gerken, northwest of Orange, a ridge passes through the vineyard from northeast to southwest. The vines were the Muscat of Alexandria, all set at one time and had done well in all parts of the vineyard prior to the disease. After its appearance the vines upon the ridge died much before those in the level portions of the vineyard. On July 22, 1889, the temperature of the soil on the ridge at a depth of 18 inches was 81°, while that of the level portion of the vineyard was 78°. Owing to the presence of vines on the level land, the soil there appeared to contain less moisture than was present in that on the ridge. Had the vines been still growing upon the ridge it is likely the lack of moisture would have induced a still higher temperature. There is, however, sufficient difference to be worthy of note when it is connected with the earlier death of the vines.

For the purpose of comparing that portion of the Santa Ana Valley next the foothills, where the vineyards had mostly disappeared, with a part of the valley nearer the river, where vines still existed in a bearing condition, the soil temperature was taken at both places. These readings were made in both instances at 1 p. m., August 23 to 29, 1889, inclusive. The tests next the foothills were made in soil north of and near the ranch house of the D. Hewes ranch, southeast of McPherson. On the lower land the tests were made on the ranch of Mr. F. Gerken, northwest of Orange, where the vines were still bearing. In both cases the thermometer was sunk 18 inches below the surface, and the tube containing it was closely packed about with earth. The instrument remained in the covered tube, except when removed for reading. The instruments used in the two places were carefully compared and their variations considered in the final results.

The following table gives the records:

Temperature of soil at 18 inches below the surface southeast of McPherson (Hewes ranch) and northwest of Orange, Cal. (Gerken place), from August 23 to August 29, 1889.

Date.	Hour.	Temperature on the Hewes ranch.	Temperature in the Gerken vineyard.
1889.		°	°
August 23	1 p. m.	81	78—
August 24	1 p. m.	81	78—
August 25	1 p. m.	80	77+
August 26	1 p. m.	80	77+
August 27	1 p. m.	80	77—
August 28	1 p. m.	79	77—
August 29	1 p. m.	80	77

The mean temperature on the Hewes ranch was 80.14°. This, however, must be reduced by 0.28°, which was the variation between the two thermometers used, leaving a true mean of 79.86°. The mean temperature on the Gerken place was 77.28,° making an average variation for the seven days of 2.58°. Slight similar variations of temperature are noted in both places from day to day, showing that the instruments worked correctly.

CHANGE OF CLIMATE.

In 1786 it was written that the climate of California differed—

a little from that of the southern provinces of France; at least the cold is never so piercing there, but the heat of summer is much more moderate, owing to the continental fogs which reign there, and which procure for the land a humidity very favorable to vegetation.

Forbes[1] says respecting that statement that—

the southern parts of the country are not entirely exempt from the periodical rains and long droughts to which the tropical climates in this vicinity are liable. * * * The periodical rains of the south, which are very heavy, begin to fall in November and continue until April.

It would be of interest to consider early records of climatic conditions, but no accurate statistics were kept which allow of comparison, and hence there is little hope of being able to show that the present features of climate are the same as those of past years. There is, however, a reasonable way of approaching the question. Any change of climate that could produce the effect known as the vine disease of southern California must have been sudden and marked. It has already been shown that no such change has occurred. So, too, any such change must also have been confined to a small part of the country, as the death of the vines was at first. From the death of the young vines it has been shown that if climatic changes were the cause of the trouble, those changes must still exist, but vines are now prospering in regions only a little way removed from the dying vineyards.

TEMPERATURE AND SWEETNESS OF FRUIT.

The relations of elevation, of shade, and of sun to the disease seem to harmonize with that of sweetness of the grape. There also seems to be a relation between the varietal sweetness of fruit and the development of the disease. This view has arisen from personal observation, and is in accord with the belief of others. It seems to be beyond question that in one variety, conditions being equal, a vineyard so located as to bear sweet fruit is apt to die earlier than one located where it lacks this quality.[2]

[1] California, pp. 163, 164; also *Voyage de la Pérouse.* Tom. II, pp. 255, 256. Paris, 1797. Written in 1786.

[2] Mr. L. J. Rose, of San Gabriel, writing in October, 1889, says that it would seem as if the disease had the power of selection, and chose such varieties of vines as bore the sweetest grapes. The young foliage of the Muscat and Mission is also first eaten by rabbits, while the Zinfandel and kindred acid varieties are untouched or devastated last.

This fact seems to harmonize perfectly with the statements respecting elevation and warmth of soil. In buying grapes for raisins or for wine it is the custom to test the amount of contained sugar by the saccharometer. It has been thus shown that certain elevated portions in the Santa Ana Valley produced fruit of much higher saccharine qualities than other places in the valley. Inquiries as to these places in connection with dates when vines died there have led to the conclusion that the vines producing the sweetest fruits were the first to die from the disease. The gravel lands near McPherson may be compared with the cooler lands by the Santa Ana River for illustration. Respecting the early death of those varieties of vines bearing the sweeter grapes there is not complete evidence. It is a fact, however, that several of the sweeter varieties die first, the old Mission being a prominent example. To establish the general truth of this proposition would be very difficult, as season and location must of necessity be taken into account. It should be added that there is good evidence that grapes grown on diseased vines are not as sweet as upon vines not diseased, this being the result of the action of the disease on the fruit and not bearing on the other proposition.

A review of the matter of temperature from the time the disease began, and a study of its bearings on the disease, is not wholly satisfactory. Certain general principles or relations of heat and the workings of the disease are, however, clearly defined. It may be said:

(1) The winter of 1883–'84, with the conditions of humidity then existing, was the most exceptional in climatic features of any period just prior to the development of the disease; (2) the hottest portion of the season is most favorable to its development; (3) great heat favors the early death of the diseased vine; (4) the more heated the soil the more it favors the early death of vines from disease; (5) slight elevation of the vines favors their early death; (6) great sweetness of fruit and the early death of the vine frequently coincide.

WINDS.

One of the theories advanced to account for the death of the vines is that it has been caused by the heated winds which blow occasionally from the deserts back of the San Bernardino Mountains. To one unacquainted with their great force and heat these winds will seem of less consequence than to anyone who has felt them. These northern or Santa Ana winds, as they are locally called, are very strong. In the diseased districts they usually come from the Cajon pass through the San Bernardino Mountains, and after blowing with great violence across the valley, near San Bernardino, enter the pass of the Santa Ana River and blow to the southwest across the Santa Ana Valley to the sea. The thermometer often rises very high during one of these blows. I have myself seen it stand, in a shaded but somewhat confined situation, at 111°. On the place of Mr. J. F. Bennett, 2¼ miles north of Orange, the

Santa Ana blowing in the fall of 1889, and additionally heated by mountain fires, burned the fig trees so as to destroy the leaves and kill the bark and tips of the twigs on the northeast side. In a week's time new leaves appeared and no permanent damage resulted.

Mr. Benjamin Pratt in writing to the Division of Vegetable Pathology, under date of September 2, 1888, says, respecting this theory, that doubtless the winds have blown through the Santa Ana cañon ever since the cañon was formed, and both wild and cultivated vines have grown in the face of these winds for a hundred years, and no damage was done until two or three years ago. He queries whether the big vines in the cañon have been changed in their resisting power, or whether the virulence of the winds has changed. However, both protected and unprotected vines have fared the same.

These winds were felt in 1847 as they are felt to-day. W. H. Emory, during his expedition through southern California in that year, writes on January 6:

> To-day we made a long march of 19 miles to the Upper Santa Ana, a town situated on the river of the same name. * * * The wind blew a hurricane (something very unusual in this part of California [?]) and the atmosphere was filled with particles of fine dust, so that one could not see and but with difficulty breathe.

On the 7th, he continues:

> The wind continued to blow violently, which the enemy should have taken advantage of to attack us. Our weapons were chiefly firearms; his, the lance; and I was quite certain that in such a gale of wind as then blew the difficulty of loading our arms would have proved a serious matter.

It should be added that the extensive vineyards of Anaheim thrived in the track of these winds for more than a quarter of a century.

These winds have been compared to the sirocco of Algeria, and M. Mores is quoted as authority for the statement that Folletage has been manifested where it blows. Dr. Foëx, director of the agricultural school at Montpellier, has told me that the effect of this wind on vines in Algeria is the same as that seen under any hot and withering wind, and is not Folletage. A personal inspection of the vineyards of that country has shown Folletage to be rare, and nowhere in several hundred miles of travel has there been found any indications of it spreading over any extended region or resulting from these hot winds. This is negative evidence, to be sure, but the effects of hot winds where seen were entirely different from Folletage. An extensive vineyard, which had been burned by a fire in undergrowth near by, was examined at Duvivier August 7, 1890. The heated air had passed over the vines and had burned about the margin so as to kill the foliage and many of the canes. Instead of the leaves falling from the canes they clung to them in a dried condition, only a few bare canes being observed in a large number of vines. The leaves and canes were wholly dried and turned a cinnamon brown. Only the tip of the cane was black, the rest looking as if it were properly ripened. The fact of most importance is

that the portions left alive, whether of cane or stock, were sending out new shoots. In some cases these came from near the end of the cane, which had all the dead leaves hanging to it. In other instances they came from the stock near to or at the surface of the ground. No matter from what part they arose the shoots were invariably as fresh and green as any ever seen upon a vine. No spots or other imperfections not on normal leaves were observed, except where some fungous pest had attacked them. New flower bunches were forming as upon spring growth. The grapes were dried upon the vine, but they were red and unlike the shrunken bunches in California. I can see no reason why air heated by passing over a desert and that heated by passing over fires should act in a dissimilar manner.

CHAPTER VIII.

TREATMENT, VARIETIES, AND GROWTH OF VINES.

CULTIVATION.

Those who have not visited California very naturally desire to know if there are any peculiar features of cultivation in the diseased district. It has been interesting to compare the systems of California with those of foreign countries, but there is nothing peculiar about the California systems. The vines are cared for after the methods in use in many of the more extensive European vine districts. Throughout many of the vine regions of Italy and Sicily hand cultivation is largely practiced, but this is owing to necessity or from motives of economy. Extensive regions in France are largely cultivated with horses or oxen, and there is little difference noticeable between the finished work of the vineyards of southern California and those of southern France. In fact, it is a French system which is generally practiced in California. Vines, under all systems of cultivation, have died, as well as those which were never cultivated at all. The nature of the soil in many of the California vineyards requires the constant use of the plow and cultivator to prevent drying out. The cultivation of vineyards grown on sandy soil has been quite perfect. To say that the death of the vines was in any way a direct result of the system of cultivation involves the assumption that none of the hundreds of experienced vineyardists who have lost their vines understood the proper systems. As a matter of fact, the dead vineyards have in most cases had good and proper care. The young vines have been properly treated to induce the formation of deep-feeding roots, adapting them to withstand the long dry seasons, and all necessary precautions in summer cultivation have in most cases been taken.

PRUNING.

Like nearly everything else in connection with the situation and care of the vine in California, pruning has been blamed for the death of the vineyards. Mr. W. G. McPherson, in a letter of September 23, 1889, writes, in relation to the theories for explaining the death of vines, as follows:

> Every person that could write a newspaper article has had a theory as to the cause, and among them are: Too deep cultivation; too much irrigation; not enough irrigation; exhausted soil; natural poverty of soil; want of lime in the soil; our hot, dry north winds; too short and too early pruning.

To show that pruning has no important bearing on the disease it is only necessary to cite the various systems of pruning under which vines have died.

Concord, Catawba, Delaware, Ives, and Isabella varieties, grown by Mr. Fred. Rohrs, near Santa Ana, pruned high and staked, as in the eastern United States, have all died. These vines were set in the spring of 1884 as two-year-old rooted cuttings from Kelley's Island.

The system of short pruning in practice in nearly all the best vineyards of the world was followed in the diseased districts. Throughout southern France, from Montpelier to the Rhone and the sea, hardly any other system is in use. In Sicily, at Milazzo, Catania, Syracuse, Giarre, and Riposto, Victoria, Palermo, and over the western end of the island to Marsala and Trapani, nearly or quite the same system is practiced. All the great Algerian vineyards and many of those in Spain are pruned in the same way. If this method of pruning had a marked weakening effect on the vine it would certainly be manifested in some of the European vineyards. Further than that, the same system was practiced for a century in southern California with good results, prior to the advent of the disease, and is still followed in other parts of the State with success.

Long pruning or the entire want of pruning has failed to save the vines. Arbor vines both of *V. vinifera* and American stock have died as commonly and completely as those pruned short. Even occasional wild vines, never pruned, have died.

Through the region now denuded all seasons for pruning have been tried. Vines summer-pruned and those not summer-pruned have alike died. Vines have died which were pruned during all months of the dormant season. The vineyard of W. G. McPherson, situated at Westminster, was always pruned when most dormant, between December 10 and January 15.[1] These vines died like all others. This is only a single illustration of what is true for hundreds of vineyards.

It is safe to say that nearly all the many approved French systems of pruning have been practiced in the different parts of the affected districts and that none of these have seemed to vary the results. No system of pruning has saved a vine, and pruning is certainly not the immediate cause of their death.

CUTTING BACK.

Owing to the growth of seemingly healthy secondary shoots or "suckers" from the base of diseased vine stocks, it has been thought that by removing the top of the vine a new and healthy top might be formed from these shoots. With this hope numerous vine-growers have cut back some of their vines as an experiment.

Henry Muffelman had a vineyard of 9 acres of Muscats near Orange. After the disease had developed here in 1886 he cut back about 1,000

[1] See Vineyard Record, No. 4.

vines, some 2 inches below the ground. This was in the fall of 1886. In 1887 they reproduced small tops, but bore little. During the early part of the season the new growth appeared healthy, but at the heat of the season the leaves showed the yellow markings. In the fall of 1887 the canes were pruned so as to leave but three buds on each, close to the surface of the ground. Most of these vines were dead in 1888; a few came out in the spring, but amounted to nothing, and they were all removed in the spring of 1889.

Mr. M. Nisson, at Santa Ana, had many grapes fail to mature on his vines in 1886. In 1887 the disease became well marked and many vines which failed to produce thrifty tops in the spring were cut off even with or below the surface of the ground, and the suckers allowed to grow. Mr. Nisson says these tops became so badly diseased that they were worthless at the close of the same year. Mr. W. W. Pratt, north of Orange, cut back close to the ground several dozen vines. The shoots from the decapitated vines were more thrifty than those from vines not thus cut back, but no vines were saved. Others have met with the same results.

It has been almost if not quite without exception that vines cut close to or below the surface of the ground, or trimmed to remove the long runners which were diseased, have ultimately died. There are some evidences that vines which have been cut back will retain their vitality longer than others. About 2 miles northeast of Orange was a 3-acre vineyard composed of numerous varieties, and set 8 by 8 feet in January, 1874. In February, 1877, every alternate row of vines was cut off, with the object of planting trees between those remaining. In June, 1881, Mr. O. Handy, who was in charge, allowed these decapitated vines to form a crown close to the surface of the ground. They bore a crop of grapes one year after the uncut vines were entirely dead from the disease.

This record also illustrates the fact that vines grown close to the surface of the ground are slower to succumb to the disease than those trimmed higher; and it throws doubt on the effect of cutting back, for in this case it was not the removal of diseased wood which preserved the vine, as the cutting back was done years before the disease appeared. It may be, then, that vines cut back are aided in retaining life because they have less top to support, and not through the removal of the diseased wood.

Just south of Santa Ana, a road was cut through a Muscat vineyard during the time of the "boom," and about the time the disease was beginning its destructive work. At the collapse of the "boom" this street was neglected and became grown up with Malva and other weeds. The progress of the disease was marked in the adjoining vineyard and the growth of canes was short and stunted on those vines still alive in 1889. The vines cut back among the weeds in the neglected street had sent up shoots, and canes were found over 10 feet in length and with

abundant foliage. This condition of vines that had been cut back has been noted all through the worst affected district, and the above is only illustrative of the general facts.

The facts observed indicate that vines can not be saved from death through the action of this disease by being cut back to the surface of the ground either before or after they become diseased. Although they are in some cases preserved for a time by this severe pruning, it seems largely due to the diminished demand upon the root system by reducing the size of the top.

To illustrate what should be the effect of cutting back vines were they healthy, an extract is here given from a letter of Mr. A. E. Maxcy, of Vineyard, San Diego County, under date of December 9, 1889. He had a vineyard planted on rich, loamy soil in 1859. In 1886, having noticed a falling off in the size of the vines, he cut them down level with the earth and raised a sprout from the stump as an experiment. He says: "They are lusty vines again, and will give a large crop this coming season." Here is a vineyard of Mission vines, the variety most susceptible to the disease, which after a quarter of a century of thrifty growth is renewed by simply cutting back. This record is interesting when compared with the above recorded results in the affected district, where all vines die which are cut back.

GRAFTING DISEASED STOCK.

From the fact that vines of all varieties have died of this disease when grown on their own roots, few efforts have been made to reproduce tops by decapitation and grafting with other stocks. There is, however, one experiment bearing on this subject. Mr. Fred Rohrs, of Santa Ana, had a few Mission vines that failed to come out well in the spring of 1885. These vines were sawed off below ground, and were grafted to Bergers. The grafts caught and made a little growth, but showed early in the season that they would not do well, dying in the heat of 1885. In the spring of 1886 the stocks were sawed off a second time below the ground. Berger grafts were again set, but these failed to take. All the vines died.

From what is known of the resistance of varieties it is almost certain that none of the finer kinds could have been grown by grafting on diseased stocks. It is possible the Jacques might have lived in some instances, or under certain favorable conditions. This vine has died in some places, however, and even if it could have been maintained on diseased stock, it would rarely have been used on account of the nature of the fruit.

GRAFTING RESISTANT STOCK.

Had Phylloxera existed in southern California prior to the advent of the present disease, plenty of illustrations of the action of this disease

on vines grafted upon native roots could have been found. As such was not the case, few instances exist of native or especially hardy stocks being used as supports for the more tender varieties. The only cases of any extent and importance that were found where native roots have been grafted with *vinifera* tops, are the Packard vineyards at Pomona and Lordsburg. The Lordsburg vines were Bergers and were grafted on *Vitis Californica* roots in the winter of 1884–'85. The hardy stock was obtained from Mr. John Rock, of San José. Rooted vines were procured and were grafted with great care. Mr. Packard says[1] that only about 2 per cent of the grafts failed to take and produce tops. This vineyard has produced well and has grown very thriftily.

Although the vine disease had not worked such widespread destruction among the vines about Pomona prior to 1889 as it had elsewhere, yet it was desirable that these vines should be examined and compared with nongrafted stock. To ascertain whether any beneficial results had been obtained from this experiment, the vineyard was visited and carefully studied. The vines were found to be more or less generally diseased, but like most of the vineyards in the vicinity were still bearing good crops. Nevertheless the total output for the season, Mr. Packard said, would be reduced about 100 tons. On one part of the grafted Berger vineyard, where the subsoil favored the earlier development of the disease, the vines were badly affected. The canes were dying back from the ends, and many had prematurely shed their leaves. Dried grapes were also seen, although they were not especially abundant. The canes were irregularly spotted with the ripe and green wood, as elsewhere on diseased vines. By comparing the grafted Berger vines with those adjoining which were not grafted, the grafted stock was seen to be nearly or quite as much diseased as the ungrafted. Some of the earth was removed from a few of the worst diseased grafted vines so as to expose the place of the graft. Suckers of the *Californica* stock and the enlarged body of the vine clearly demonstrated in each case examined that the Berger tops were wholly supported by the *Californica* roots. One vine had lost nearly all of its leaves and the canes were unripe and dying, while another, also wholly on *Californica* roots, was dying in much the same manner. Growing among these badly diseased Berger vines was one of the native vines which had failed to carry its graft and had formed a *Californica* top instead. The foliage of this vine was luxuriant. The canes were properly ripened and the number produced from this one stock was remarkable. I counted 123 good long canes. These facts seem to point strongly to the conclusion that to be effectual the resistance to disease should be above the ground. Why else should Berger vines on native roots be in every way as badly diseased as if upon their own roots, while among them was a wild vine producing and ripening 123 canes on a single stock. Only, it would

[1] See letter in the report of the viticultural work of the college of agriculture, University of California, for 1885 and 1886, pp. 147, 148.

appear, because it had a more hardy top than the Berger. The case affords no evidence that *vinifera* stock could be saved from the effects of the disease by being grafted on hardy native stocks.

SEEDLINGS.

It is not a common practice in southern California to grow vines from seeds. Seedlings often occur, but they are neglected and no reliable records could be found concerning the effect of the disease upon these scattering vines. Probably the best evidence is to be derived from the death of occasional wild vines which, presumably, are all or nearly all of seedling origin.

At Anaheim a few Mission vines had been grown from seed on the place of Mr. Charles Hille. Mr. Hille took dried Mission grapes, in the spring of 1888, after the death and removal of all the old Mission vineyards about Anaheim, and planted them in a trench along the north side of his house where they had plenty of water and some shade. These seeds sprouted and grew through the season of 1888, producing vines a foot or less in length, with thin and light wood. In the spring of 1889 some of the vines were transplanted. Most of them were dead on September 7, 1889. Two of those remaining showed the effects of the disease upon the leaves. On one vine, left in the original location and which had made a growth in 1889 of about 3 feet, the leaves were nearly all yellow and badly marked by the disease.

From the few data on this subject available, all that can be safely said is that there is no evidence thus far which proves seedlings more resistant to the disease than vines grown from cuttings. Were they strongly resistant we would, without much doubt, find them still growing in the affected district, and public attention would have been called to them long ago. It would be well worth while, perhaps, to institute somewhat extended experiments with seedlings in this region.

HARDINESS OF VARIETIES.

The effort to find a wholly resistant variety has brought to light many facts bearing on the hardiness of the different varieties of vine grown in the affected district. The degree of resistance has been considered in two general ways: (1) By comparing vines of different varieties of the same age and similarly conditioned; (2) by learning in case of certain stocks grafted to others whether the life of the combined vine was longer or shorter, where disease existed, than was the life of the same varieties separate and ungrafted.

The matter of arranging varieties in anything like a proper order of resistance is rendered exceedingly difficult by the numerous influencing conditions. The only classification that can at present be made is a division of the most commonly grown vines into three classes, as follows: (1) Those of least resistance; (2) those of medium resistance; (3) those of most resistance.

Of the *V. vinifera* varieties the Mission may be taken as the type of the first class. This vine appears the most susceptible to the influence of the disease. The Muscat of Alexandria may be taken as a type of vine representing the second class, while the Flaming Tokay is typical of the most resistant class of *vinifera* stock. All *vinifera* varieties grown here may be placed in one or another of these three classes. Some of them vary much in different soils and it is hard to arrange them, while others seem to stand on intermediate lines. The names here used are the ones given by the growers themselves, but as this report is more especially intended for those who are using these names no time has been given to synonomy. It should be said that the Mission vine properly forms a class by itself on account of its exceeding susceptibility to this disease. The Sultana, which is an easily affected variety, has been placed with the Mission, but it might just as properly be classed with the Muscat group, Class II.

Class I. Mission group	Mission. Sultana?
Class II. Muscat of Alexandria group	Muscat of Alexandria. Malaga.[1] Zinfandel. Golden Chasselas. Berger. Kleber. Rose of Peru. Traminer. Riesling. Black Morocco. Victoria. Hungarian. Mataro. Rose of Italy. Catawba. Concord. Ives. Isabella. Delaware.
Class III. Flaming Tokay group	Flaming Tokay. Black Malvoisie. Lenoir (Jacques). Vitis Californica. Native vine of southern California. Vitis candicans (Mustang).

There are other varieties of both American and *vinifera* stock which might be added to Classes II and III; and some uncertainty exists in regard to the proper place of some of the varieties already given. Of these numerous varieties all will die from the effects of the disease, unless it be *Vitis Californica*. The southern species of native grape certainly dies from this disease, and there is little doubt *V. Californica* would also have died from its effects had it been grown well above the ground in the affected district.

[1] The vine known in southern California as the Malaga is much more resistant to the disease than the Muscat of Alexandria, and this vine should be considered when new vineyards are set.

Of grafts I have seen and learned of the following within the limits of the affected counties:

Mataro on Mission.
Mataro on Muscat.
Mataro on Malvoisie.
Carignan on Muscat.
Carignan on Malvoisie.
Carignan on Mission.
Grenache on Malvoisie.
Grenache on Mission.
Grenache on Muscat.
Berger on Mission.
Trousseau on Mission.
Jacques (Lenoir) on Muscat.
Muscat on Mission.
Isabella on Chasselas.
Zinfandel on Tokay.
Emperor on Mission.
"Verdelhot" on Muscatel.
Tokay on Mission.
Berger on Vitis Californica.
Sultana on Malvoisie.

Mr. H. Yount, about a mile southeast of Santa Ana, had Carignan, Grenache, and Mataro vines on Muscat and Malvoisie roots. He says each of the three grafts lived a year longer on the Malvoisie roots than on the Muscat roots. He also had Carignan and Grenache vines grafted on Mission roots, and those growing upon Mission roots died a year before the same varieties on Muscat roots. We have evidence here that hardiness of roots tends to prolong the life of the grafted stock as a whole. But unfortunately it does not agree perfectly with observations I have thus far been able to make. I believe that resistant stock will not answer the purpose of preventive or cure. The observations on Mr. Packard's place do not agree with those given by Mr. Yount, but it is still possible that the Packard vineyard will retain life longer than an ungrafted vineyard. Time alone will decide.

On the place of Mr. G. Mirande, of Pomona, Trousseau vines have been grafted on Mission stock. Mr. Mirande said that the grafted vines died earlier than the Mission vines alone. Thus grafting upon a tender stock seemed to result in a weak vine, the top not being sufficiently hardy to aid the root.

On the place of Mr. Langenberger, at Anaheim, was a Muscat vineyard planted in the winter or spring of 1878.[1] The ground had been set in 1857 to Mission vines, since removed. In 1882 the Muscats were sawed off 4 inches below the ground and grafted to Lenoir (Jacques.) This vineyard has grown vigorously through the whole time of the disease, while Muscat and other *vinifera* varieties in adjoining fields died. The vines were large and only a few of them have died. At present there are apparently no more of these vines dying. It became an interesting question to see whether these Lenoir vines were growing still upon the weak Muscat roots. In such a case, the fact could not well be avoided that a hardy top may preserve a weak root. It would also seem to point to the top of the vine as the seat of the disease. For the purpose of learning the facts an examination of the root system of a number of these grafted vines was made on October 17, 1889. The first one examined was found in the following condition: Nearly all the leaves had been shed, but it had resisted the disease with much

[1] See plat of Anaheim, lot "B–5."

success. Both the first and second vines showed distinctly the enlargement of the stock where the split graft had been made. No. 1 showed the split, while No. 2 showed only the cut end of the original Muscat stump. In each vine there were two small roots coming from above the graft while the great portion of large roots came from the bottom of the Muscat body. There seems no reason to doubt that the vines were supported by the Muscat roots. From the examinations made, and the fact that the entire vineyard was grafted only just below the surface of the ground, it may be fairly said that the Lenoir top, owing to its superior resisting qualities, had preserved the Muscat stock far beyond the period when it would have died had there been no hardy top graft. This had been done, too, at Anaheim, the very center of infection.[1]

Mr. F. Schroeder, of Santa Ana, had Muscat vines grafted on Mission roots. The grafted stock lived longer than the ungrafted, but he thinks this may have been in part due to the fact that the Muscats had formed roots of their own. Other facts in hand tend to show that Muscats on Mission roots will outlive Mission vines alone.

The following extract from a letter by Mr. Samuel Shrewsberry, who had some arbor vines in the Santiago cañon, east of Orange, gives another example of the same kind. Mr. Shrewsberry writes:[2]

> I had three Chasselas vines on an arbor that bore abundantly for years. Into one of these I grafted an Isabella 3 inches below the ground surface. My vines were 14 miles from the nearest vineyard. The Chasselas died in 1887. Now the Isabella grafted on the Chasselas stock is dying [two years after the others]. My other Isabellas are perfectly healthy—those that had Isabella roots. They are all on the same arbor.

Mr. Shrewsberry's Isabella vines will also be apt to die, as many of this variety growing upon their own roots have died in different parts of the affected district.

To conclude, it may be said: (1) The power of resisting this disease varies greatly in different varieties; (2) the wild American species seem to be the most resistant, but this appears to depend more largely upon the top than the root; (3) roots of hardy stock have not yet been shown to preserve tender tops for any great length of time; (4) hardy tops grafted on tender roots have a strong tendency to preserve the latter.

GROWTH OF CUTTINGS.

There is a belief prevalent in California that cuttings from diseased vines are themselves diseased. This belief is not confined to a few of limited observation, but is very general and has adherents among the most thoughtful and observing vine-growers of the region. It has gained its hold from the efforts made to replant new vineyards after the death

[1] It has since been reported that these vines have at last become worthless, and have been or soon will be removed.

[2] Letter of August 27, 1889.

of the old vines. This claim is a remarkable one, and is one which will call forth surprise from anyone acquainted with ordinary vine diseases. But it is met with everywhere and is believed by everyone who has attempted to set a new vineyard. It has been my effort to collect facts bearing on this subject throughout the field work, and the following are taken from my notes:

GROWTH OF DISEASED CUTTINGS.

Throughout the State the common practice is to form new vineyards from cuttings made of properly matured wood from the adjoining vineyards; or the cuttings may be brought from a distance, for the sake of the variety or securing a greater supply. The cuttings are usually made when the vine is dormant. In some cases they are heeled in and allowed to root for one season before setting in the field, but the more common practice is to set the cuttings in their proper places in the field before being rooted. Planting is generally done before the close of the heavy spring showers, so the conditions will be favorable to growth. In the drier districts these newly set cuttings are irrigated, this being the practice over much of the Santa Ana Valley. The stand usually obtained in former years from healthy cuttings was, as near as could be learned, from 90 to 96 per cent. With those having favorable soil and giving proper attention to the quality and treatment of the cuttings the percentage rarely dropped below 95. By referring to Plate I an idea of the uniformity of stand obtained may be had. In this case, however, rather more than the usual number of vines had failed to grow.

In considering the growth of diseased cuttings, or those taken from the region of the disease, I will first give the history of cuttings set somewhat before the appearance of the disease, thus allowing of comparison with later results:

1881. Mr. M. Nisson, of Santa Ana, set a Malvoisie vineyard in the spring of 1881 or 1882, and obtained a good stand. He noted disease first in these vines in 1886 and they were virtually dead in 1889, and a portion or all were removed in the winter of 1889–'90. Mr. Henry Kroeger, of Anaheim, set a Queen Victoria vineyard in 1881. Disease appeared in these vines in 1885; they died in 1886, and were removed in 1887. Mr. W. G. McPherson, of McPherson, set 20 acres of vines in the spring of 1881. They showed disease in 1886, died in 1887 and 1888, and were removed in February, 1889. Mr. A. Reuter, of Santa Ana, set a Berger vineyard in 1881 or 1882. In 1884 they bore 8 tons per acre. In 1885 and 1886 the yield was 9 tons per acre. In 1887 they produced but short growth and only 2 tons per acre. In 1888 they were virtually dead. Disease was here first noted in 1885; three vines were dead in 1886, and the general death was in 1887 and 1888.

1882. Mr. R. M. Hazard, of Tustin, set 10 acres of Muscats in the spring of 1882. He saw disease in 1885, but the yield of the vines was, in 1885, 474 boxes raisins; 1886, 1,360 boxes; 1887, 350 boxes; 1888, 170 boxes. The vines virtually died in 1887 and 1888. Dr. A. L. Cole, of Santa Ana, set a Muscat vineyard in the spring of 1882. The vines showed disease in 1886 or earlier and virtually died in 1888, and were removed in 1888 or 1889.

1883. Mr. E. Haworth, of El Modena, had 15 acres of Muscat vines near McPherson in 1887. These vines had been planted in the spring of 1883. They bore a full crop in 1886, 75 per cent in 1887, and in 1888 only a ton to 15 acres. They were removed in 1888–'89. Mr. Henry Kroeger, of Anaheim, set a Zinfandel vineyard in the spring of 1883. Disease appeared in 1885, and they died in 1886–'87 and were removed in 1888. Mr. W. G. McPherson, of McPherson, set vines in the spring of 1883, which became diseased in 1886 and died in 1887–'88, and were removed in February, 1889. Mr. Snyder had a Muscat vineyard set in the spring of 1883 opposite the mouth of the Santiago cañon. Disease was seen in these vines in 1886, and they died in 1887 and were removed that year. Mr. C. J. Hough, of Garden Grove, set 3 acres of Muscats in the spring of 1883. Disease was seen in 1885–'86 and the vines were worthless in 1888.

1884. Mr. F. J. Kimball, of McPherson, set a Muscat vineyard in the spring of 1884. Disease appeared in the spring of 1886. In 1887 the vines were badly diseased, and they were worthless in 1888. Mr. F. Gerken, of Orange, set a Muscat vineyard in the spring of 1884. A little disease appeared in 1886, but the vines bore good crops up to 1888; and a fair crop was gathered from a portion of the vineyard in 1889. The vines were badly diseased in the summer of 1889. This is an exceptionally slow death, owing to the sandy nature of the soil. Mr. A. M. Aldrich, of Riverside, had 3 acres of Muscat vines set in the spring of 1884. Disease seems to have appeared in 1887, but it is working slowly. Vines were rather badly diseased in 1889. Mr. John Evans, had a Muscat vineyard set in the spring of 1884 near Santa Ana. The progress of the disease is not known, but the vines were dead in 1889. Mr. Henry Hockemeyer, of Orange, set a Muscat and a Sultana vineyard in the spring of 1884. The Muscat cuttings came from the vineyard of Mr. John Gathman, southeast of Orange. The cuttings were made about January, 1884, and after being heeled in during the winter were planted toward the last of March. When set, the roots had not started. The vines have since died. The Sultana cuttings were procured from Riverside the same season, and the vines produced have also died. The Sultanas died rather earlier than the Muscats. It should be noted, in passing, that the winter of 1883–'84 is bridged over by these home and Riverside cuttings, and yet the vines died of the disease.

Mr. F. Rohrs, of Santa Ana, planted a Berger vineyard in April, 1884. The cuttings were procured from older vines on his place. They made a good growth in 1884. A few grapes were gathered from them in 1885. They were staked and in good condition that year, and in 1886 they made a good spring growth and bore a fair amount of grapes for young vines, but in the heat of the season some of the fruit dried. They were pruned in the winter of 1887, but in the summer all "went back." The cuttings showed their vigor by their growth and production. Here the winter of 1884 is again bridged by cuttings and of another variety. These records should be contrasted with the history of cuttings set in later years. Mr. C. J. Hough, of Garden Grove, set 8 acres of Muscat cuttings, from the place of Robert Blee, near Santa Ana, in the spring of 1884. Disease was seen in 1885–'86, but a few grapes were obtained as late as 1888, though the vines were virtually worthless by the close of that season. Some of these cuttings were made before the heavy rains of the winter of 1883–'84, and some of them were made during this wet period.

1885. Mr. John Roth, of Orange, had 10 acres of Muscat vines set in the spring of 1885. These vines were on loose, sandy soil, and consequently lived longer. Owing to the favorable location the vines bore 9 tons to the 10 acres in 1888 and a smaller crop in 1889. Dr. A. L. Cole, of Santa Ana, set a Muscat vineyard in the spring of 1885. Disease appeared in 1886 and the vines died in 1888 and were removed in 1888. W. G. McPherson, of McPherson, planted 2 acres of cuttings in the spring of 1885, which nearly all died in 1888 and were removed in 1889. Mr. D. Hewes, of McPherson, set 75 acres of Zinfandel vines in the spring of 1885. They grew well, and in the summer of 1886 produced a crop worth $1,475. The vineyard was pruned in the spring of 1887 up

to about April 5. The vines bled considerably. They formed a short growth. The growth soon died back, and the entire vineyard was worthless by fall.

1886. Mr. Peter Ainsworth, of McPherson, had an old Muscat vineyard from which he made cuttings during the winter of 1885–'86. He did not notice disease in the old vines till the spring of 1886. They bore a full crop that summer, and a fair crop in 1887. Two and a half acres of cuttings from these vines were set out, in the spring of 1886. They made a good growth during the summer; but in the fall, when they shed their leaves, the canes were imperfectly ripened. This vineyard was very badly diseased in 1887, and virtually worthless by that fall. Mr. T. H. Powers, of Garden Grove, had 4 acres of Muscats set in the spring of 1886. The vines bore a few grapes the first season. They had half a crop for young vines in 1887, 500 pounds per acre in 1888, and only enough for home use in 1889. Mr. C. J. Hough, of Garden Grove, set 12 acres of Muscat cuttings in the spring of 1886. These came from the young vines set in 1883 and 1884. Little difference was observed between the behavior of these cuttings and those set in 1883 and 1884 on the same place. In 1888 the crop amounted to very little, and the vines were practically worthless at the close of the season.

1887. Mr. H. D. Clark, of Orange, procured Muscat cuttings from Mrs. Hager's place on gravel land where some vines showed disease and set 30 acres in the spring of 1887. Some of these cuttings started slightly, and showed disease in the first growth. Other vines showed disease before fall, though a good percentage grew fairly well through the season. Nearly all showed disease in the spring of 1888 on the first growth, and became so badly diseased by June that they were considered beyond hope and were plowed out. Another vineyard in the vicinity of Mr. Clark's was set out in the spring of 1887. Here 2,000 cuttings were selected with much care from the healthiest vines of 20 acres of old vineyard. They were carefully set in the spring and well watered. The old vines from which the cuttings were made produced a partial crop that season. None of the selected cuttings made a good top growth, but in some cases produced fair roots. In many cases the buds on the cuttings swelled and only produced a leaf or two, after which growth ceased. Not more than 10 per cent of the vines produced a cane 1 foot in length during the summer of 1887.

Mr. Frank Steskal, of Santa Ana, selected Muscat cuttings from the best vines of a diseased vineyard in February, 1887, and planted an acre of them. These cuttings were irrigated in February and April. They showed disease in July and still more in August. Only about 50 per cent began to grow in the spring of 1888 and they were all badly diseased in the fall. In March, 1889, some of them barely started, forming minute leaves, which in a few days turned yellow and fell off. They were removed that spring. Mr. E. F. Greenleaf, of Santa Ana, set cuttings in the spring of 1887. These started, but 80 per cent of them failed in the hot weather of 1887. Mr. Greenleaf says 3 per cent would be the limit of those which would fail if the cuttings were taken from healthy vines. He is satisfied the disease is in the cuttings. McPherson Brothers procured Muscat cuttings from various vineyards in the Santa Ana Valley in the winter of 1886–'87, and planted 600 acres at Phœnix, Ariz., in the spring of 1887. About 70 per cent started to grow; in July about 50 per cent were alive; and January, 1888, only 25 per cent were in fair condition. A 10-acre vineyard was also set in the Santa Ana Valley the same spring. Of these cuttings only about 60 per cent lived through the season of 1887, and but few of them made a good growth. Over one-half started in the spring of 1888, but by the fall the vineyard was worthless.

Mr. Fred Rohrs, of Santa Ana, set out a vineyard of Muscat cuttings in the spring of 1887, taken from his own Muscat vines. They showed disease in the summer of 1887, and they became so badly diseased that they were plowed out in 1888.

Mr. Nathan Fletcher, of Orange, set out 300 or 400 Muscat cuttings taken from a diseased vineyard, in the spring of 1887. About 90 per cent of these started to grow; some 60 per cent grew through the summer. Only about 30 per cent started to grow

in the spring of 1888; and not more than 10 per cent lived till that fall. Mr. Henry Darling, of Fulton Wells, procured Muscat cuttings from diseased vines near Anaheim and set out about 40 acres in the spring of 1887. The majority started in the spring, but showed the disease. They were mostly plowed out in the spring of 1888, but certain portions of the vineyard were left, and vines here died of the disease.

1888. Mr. F. J. Kimball, of McPherson, chose cuttings from the most healthy vines of his old Muscat vineyard in the winter of 1887–'88, and set out 3 acres in the spring of 1888. These cuttings were selected with care. Over 90 per cent started, but they stopped growth before the end of the growing season of 1888, and by the end of that year 95 per cent had died. Mr. Frank Steskal, of Santa Ana, selected cuttings from the best of the old Muscat vines on his place in February, 1888, and at once set about an acre. These started in the spring and grew to nearly the last of May, or while the weather was cloudy. About June 1 it became warm and growth ceased. Yellow spots appeared upon the leaves, which turned brown at the margin. They grew worse day by day, and in August many died, and 75 per cent of the vines were nearly dead. In the spring of 1889 50 per cent started to grow, but in May only 10 per cent were growing. They were then taken out. Mr. John Gathman, of Orange, set out Muscat cuttings from a diseased vineyard in the spring of 1888. They were treated with Bordeaux mixture as a disinfectant before planting. I examined them during the first week of October, 1889. One representative row contained 37 vines. Of these 35 were dead or gone. Only 5 of them had started in the spring, and 3 of these 5 had died during the summer, leaving only 2 vines at the time of the examination which bore living foliage. Thus 32 out of 37 died the first season. In the winter of 1887–'88 Mr. O. Handy had cuttings made from Muscat vines from the diseased district and planted 40 acres. Good and properly ripened wood was taken wherever found, no attention being given to the degree of disease observable in the parent plant. Hence they fairly represented the condition of the old vineyard. The cuttings were planted in the spring of 1888. About 90 per cent started and made two to three weeks' growth, which rarely exceeded a length of 6 inches. Not over 2 per cent of the vines continued to grow through the entire season. The leaves of the first growth lasted about six weeks and then began to dry and fall. The newly formed shoots began to die back, and irrigation failed to keep them growing. The dying parts turned black as in all diseased vines. The roots were but a few inches in length. Mr. Handy considers that the few vines which grew through the season were cuttings from the comparatively healthy scattering vines in the old vineyard, while the mass of cuttings which died before the first fall were from the more diseased majority of the vines, and that the order of death of the cuttings agreed with the state of advancement of the disease in the parent stock. According to Mr. Handy's view the growth of top and root sent out by cuttings represented the amount of stored vitality or starch in the cuttings themselves; that in most instances they never fully began to draw material from the earth.

1889. Mr. Frank Steskal, of Santa Ana, made cuttings in the winter of 1888–'89 from young diseased vines set in the spring of 1887. The cuttings were set in February, 1889, and were irrigated then and again in April. Only about 25 per cent of them started at all. These grew three or four weeks and looked fairly well, but when the weather cleared and the sun came out hot the growth was killed in a few days. They were taken out in June. Mr. John Gathman, of Orange, set out some cuttings from home vines in the spring of 1889. They were disinfected by dipping in the Bordeaux mixture before planting. In October, 1889, out of 62 cuttings, 12 did not seem to have started, and out of the other 50 the new growth on 41 was dead before the first week of October. This left but 9 vines living out of the 62. These had made but an inferior growth and would probably not come out the following spring, or at least not live through another summer.

1890. In the spring of 1890 Mr. S. G. Baker, of Norwalk, experimented with cut-

tings of four varieties, Mission, Zinfandel, Berger, and Muscat. Of each of these he planted 500 cuttings, all made from vines remaining in his old vineyards. Mr. Baker says his object in taking cuttings from vines in a diseased vineyard was to ascertain whether the disease had left, for many reports were afloat that the disease was over. "The yellow spots on the Muscat leaves, the dark spots on the leaves of the Bergers, and the white spots on the leaves of the Zinfandels show positively that the disease is not yet over.[1]" The Mission cuttings were taken from eleven vines that were left out of 35 acres. The soil was a rich, sandy loam which had never had vines on it before. They were never irrigated; but Norwalk is upon artesian ground and permanent moisture is reached there at a depth of 12 feet.[2] These cuttings were cultivated with the hoe and they were kept free from weeds. No treatment was given them either of sulphur, Bordeaux mixture, or other substance. The wood of the cuttings was all ripe when planted.

Summary of results.—(1) Of the 500 Mission cuttings 90 per cent started and grew well, producing a fair top; (2) of the 500 Muscats 50 per cent started to grow, but 20 per cent of these died after starting; (3) of the 500 Bergers not over 40 per cent started and 50 per cent of these died after starting; (4) of the 500 Zinfandels about 75 per cent started to grow and about 33 per cent of these "died root and branch after making 4 inches growth." These facts are tabulated below as follows:

Diseased cuttings set in the spring of 1890, by S. G. Baker, Norwalk, Cal.

Variety.	No. of vines set.	No. of vines which grew.	No. of vines which died summer of 1890.	No. of living vines in fall of 1890.
Mission	500	450	[?]	459[?]
Muscat	500	250	50	200
Berger	500	200	100	100
Zinfandel	500	375	124	251

The history of vine cutting here given, covering the period from the spring of 1881 to that of 1890, brings out some very interesting facts bearing on this problem. The cuttings set in 1881 died in 1886, 1887, and 1888, the date of 1886 referring to Anaheim. Those set in 1882 died in 1887 and 1888; no Anaheim records are included. The cuttings of 1883 died in 1886, 1887, and 1888, the 1886 date referring to Anaheim. The cuttings of 1884 died in 1887, 1888, and 1889; the date of 1889 refers to vines especially well located. The cuttings of 1885 died in 1887, 1888, and 1889, the last date referring to very favorably situated vines. The cuttings of 1886 died in 1887, 1888, and 1889, the last date here referring to vines having little vitality in 1888, but lingering on account of favorable situation. The cuttings of 1887 died in 1887 and 1888. The cuttings of 1888 died in 1888 and 1889. The cuttings of 1889 died mostly in 1889. The cuttings of 1890 were many of them dead in 1890. All these cuttings were taken from the region of the

[1] Letter dated Norwalk, March 2, 1891.

[2] See vineyard records Nos. 5, 6, 7, and 8.

disease, and were what may be called home or diseased cuttings. A glance over these results shows the source of the idea that cuttings from diseased vines are themselves diseased, but the same thing is more strongly brought out by comparing with these certain records of cuttings from healthy vines planted at the same time.

GROWTH OF HEALTHY CUTTINGS.

Prior to the appearance of the present disease cuttings produced a stand of about 95 per cent, and the vines lived an indefinite period up to eighty and one hundred years.

During the winter of 1885–'86 Mr. M. Mendelson, of Capistrano, procured cuttings of Blue Elben, Golden Chasselas, and Traminer from Napa County. They were set in the valley back of Capistrano in the spring of 1886. There were here, also, Black Malvoisie and Kleber vines set in the spring of 1882, and some Black Morocco vines set in the spring of 1883. The soil is deep, rich, black, sandy loam, and never had grapevines on it before. Irrigation could be and was practiced when needed. The situation was low and probably the depth to permanent moisture was not great. The vines were given good care. Disease appeared on the older ones first, especially upon the Kleber. Upon these the leaves showed stripes in the fall of 1887, and they were quite badly diseased in 1888, and some were removed in the winter of 1888–'89. The disease was worst on the highest spot in the vineyard, there being many dead vines here of the Malvoisie variety in August, 1889. About the 8th of September the Traminer vines were dying of the disease. The leaves were marked about the edges with yellow, which passed in between the principal and secondary veins, giving the leaf the appearance of the Lenoir leaf, shown on Plate XXI. The Golden Chasselas and the Blue Elben vines were also diseased and dying, the leaves of the latter having much the appearance of those of the Traminer. The vines were so badly diseased in the fall of 1889 that Mr. Mendelson considered them worthless, and was to remove them that winter.

In the winter of 1887–'88 Mr. O. Handy, northeast of Orange, procured cuttings of Muscats from Riverside in sufficient numbers to plant about 10 acres. Riverside was almost free from disease at that time, but since then it has developed quite slowly and some vineyards have died. There was no reason for calling these cuttings other than healthy at the time they were set, and their growth indicated their healthy condition. They were carefully planted in the spring of 1888 and grew well, and a good stand was obtained. They lived through the season, and but comparatively few signs of disease were seen among them. In the autumn of 1888 some of the leaves showed yellow markings, indicating a slight degree of disease. Other vineyards set at the same time in this vicinity from diseased cuttings were mostly dead in 1888, but the River-

side cuttings, almost without exception, started to grow the next spring as vigorously as any vines. Toward the last of May, 1889, the vines were growing finely, and had formed good tops, covered by healthy foliage. Only a few spotted leaves were seen, and these but very faintly marked. A month later the disease was strongly marked over nearly the entire vineyard, about 75 per cent of the vines showing signs of disease. On July 13, 1889, the effects of the disease were more pronounced, the leaf spotting being quite distinct in some cases. At this date Mr. Handy applied the Bordeaux mixture, which apparently aided the vines in producing a new and rapid growth. Ten days later they had produced a good new growth of from 7 to 16 inches, but disease was well marked throughout the vineyard, though the tops were of good size and a good supply of fruit was present. On September 19, 1889, the vineyard was in a deplorable condition. One-half of the vines were rapidly dying, and perhaps 30 per cent had already lost a large part of their leaves, while the tops of many more were yellow. On October 31 about half the vines retained their leaves and there was scarcely a vine which did not show the disease. On the south side of this vineyard was a hedge a few feet high. It was not high enough to shade the vines, but was high enough to break the south winds and confine the heat about the few adjoining rows, and it also drew considerable moisture from the soil near by. In the following table the upper figures are of a row of vines near the hedge, and they show a much larger percentage of badly diseased vines than the records of interior field rows.

Condition of the Handy vineyard on October 31, 1889.

Rows examined.	No. of vines in the row.	No. of vines retaining leaves.	No. of vines with fallen leaves due to disease.	Notes.
First	100	31	69	Hedgerow.
Second	100	64	36	Inner row.
Third	100	69	31	Do.
Fourth	100	68	32	Do.
Fifth	100	71	29	Do.
Sixth	100	76	24	Do.
Total	600	379	[1]221	

[1] Equal to 37 per cent.

Throughout the vineyard the vines from which the leaves had fallen were turning black from the ends. It was virtually ruined, although a large percentage of the vines came out in the spring of 1890. Some were replaced, however, during the winter with new cuttings. The badly diseased vines, those showing much dried wood, were left unpruned. Many of the vines started out in the spring of 1890, and after pruning they were well soaked with the Bordeaux mixture, but this failed to save them. They had also been treated early in 1889 with the Ongerth powder. No observable good was derived from this treatment

and the Bordeaux mixture was preferred by Mr. Handy. This gentleman writes under date of December 26, 1890, that—

the Riverside cuttings suffered some this year. Some of the vines have died, especially as far west in the vineyard as those tall pine trees on the south side of the road. From the west end of the trees to the west end of the vineyard not one-half as many vines are dead.

As I have paid no special attention to the trees mentioned I can not pass an opinion as to what the relationship of these trees to the death of the vines may be. The complete death of the vineyard is only a matter of a little time.

Mr. George Irvine, northeast of Tustin, lost a Muscat vineyard of 37 acres by the disease. He procured a large number of cuttings from Niles, Alameda County. These were disinfected, and planted in the usual way in the spring of 1889. A fair percentage took root and produced good tops. On July 31, 1889, the vines were in good condition. After the warm weather of August they began to show disease, and the appearance of disease became so marked that Mr. Irvine had the entire vineyard plowed up during the winter of 1889–'90.

Acting upon the theory that the weakness of cuttings from diseased vines is due to the action of some parasite, I have corresponded with Messrs. Bush & Son and Meissner, of Bushberg, Mo., to learn what experience they have had with cuttings from vines affected with Phylloxera or *Peronospora*. Under date of January 15, 1890, Mr. Meissner writes as follows:

Our purely native American species [of *Vitis*] are never so much affected by Phylloxera that they show ill effects from the insect, but many of them are seriously affected by mildew and other fungous diseases. When such is the case, we find the effects thereof very marked in the way that cuttings grow the first season from such diseased vines, so much so in fact that we never use any wood from vines which we know to have been seriously affected by mildew the previous season. The produce of such cuttings will be weak and puny plants, aside from the fact that the percentage of rooted plants will be reduced to a minimum as compared with the percentage of rooted plants resulting from cuttings taken from good healthy vines of the same variety. The detriment in the case of cuttings from mildewed vines results chiefly from the fact of the wood remaining immature no doubt. We should suppose that the effect of the Phylloxera on *Vitis vinifera* would be quite as damaging to the cuttings taken from diseased vines as the effects of the mildew are on our native species. As we do not grow any of the *V. vinifera* varieties (with the exception of a few grafted vines) we have had no opportunity for personal observation in this direction.

In another letter Mr. Meissner says that plants grown from cuttings made from vines previously weakened by the action of mildew may fail the first season, but after they have prospered through one season the loss the second season is small. While at Bordeaux, France, I asked Prof. Gayon if in his experience the action of Phylloxera was to weaken the vine so that cuttings made from it would die. He said that if such cuttings were planted in Phylloxera-infested ground they would root and grow through the first season, but owing to the renewed attacks

of the insect they would die the second season. On the other hand, if such cuttings were set in soil not infested by this insect, 90 to 95 per cent of them would root and prosper. This indicates that Phylloxera does not induce that marked weakness of the new wood of the affected vine which is induced under the action of *Peronospora*.

Considering the entire subject of diseased and healthy cuttings, the following generalizations seem more or less probable: (1) Cuttings made from vines in the diseased region prior to the appearance of the disease produced healthy and long-lived vines in that region; (2) cuttings made from vines in the diseased region after the appearance of the disease produced weak and short-lived vines; (3) the longer the disease has affected a vine the weaker and shorter-lived are vines grown from its wood; (4) cuttings made from healthy vines have died with all the apparent characters of this disease when planted in the affected region long after the first appearance of the disease, but such cuttings die more slowly than those made from affected stocks; (5) the evidence from the later plantings of cuttings is that the disease is actively existing at the present time; (6) the behavior of cuttings from both diseased and healthy vines, when set in the diseased region, is closely allied to that of cuttings made from healthy vines or those weakened by fungous parasites or otherwise, and which are set out where such weakening influence may still act upon them.

CHAPTER IX.

THE RELATIONSHIP OF THE DISEASE.

California has a native fauna and a native flora in many ways allied to those of western Europe and the Mediterranean region. This is to a considerable extent due to similar climatic conditions in the two regions. Owing to these similar climatic conditions the foreign vine is that most extensively grown in the State. Hence the vineyards as well as the climate, and many indigenous plants and animals with their respective pests, are more nearly related to those of Europe than they are to those of the United States east of the Rocky Mountains, and it is to Europe that we should look for the homologue of the vine disease of southern California.

Most of the worst vine diseases are native of the eastern United States, but they have passed to Europe and have there, under new conditions, produced more marked or wholly different effects. It is proper, then, in considering vine diseases for Californians, to compare them with the same or similar diseases of Europe, and to point out the effects seen there, as well as the methods adopted for relief. My recent European work has had constantly in view the situation and needs in California, and especially the condition in the southern portion of the State, hence it may be allowable and of interest to give some space to various vine diseases.

It is not purposed, however, to attempt any very extended exposition of vine diseases in this bulletin, but it is desirable to mention a few of the leading maladies which might in any way be confounded with the California trouble, and to review briefly those seeming to have any relationship to it. For convenience they will be grouped under the heads of fungi attacking the roots; fungi attacking the foliage, canes, and fruit; animal parasitic diseases; and nonparasitic diseases. As yet many of the worst parasitic diseases have failed to gain a foothold in southern California. There is scarcely any doubt that they will eventually reach that region, though it is uncertain to what extent they may be able to injure the vineyards on account of climatic conditions.

FUNGI ATTACKING THE ROOTS.

The general term *Pourridié* is applied to those diseases of the vine which are caused by root fungi. In California the roots are badly rotted on diseased vines, but the fungi which cause such widespread destruc-

tion in Europe have not been found on them. There are, however, other fungi found on diseased vine roots, but only one form has been seen which is constant enough or in sufficient abundance to require consideration. This is a species of *Graphium* which has not yet been identified with any described species of that genus, and which may be undescribed. Two or three well-known parasitic root fungi of Europe will be compared with the disease being considered.

DEMATOPHORA NECATRIX R. Hartig.

Of the parasitic root fungi of Europe, *Dematophora necatrix* probably ranks first in its widespread destruction of cultivated plants. Vineyards suffer severely from it in nearly all parts of Europe. Fruit trees of many kinds are killed by it, and although the losses are sporadic they are very great when taken collectively. More harm is done by this fungus than is generally known, even to those engaged in fruit-growing. Trees and vines fail here and there in the orchard or vineyard and the owner in the larger number of cases has little or no idea of the true cause. This is especially true in Italy in those places where trees and vines of all ages are grown intermingled in an incongruous manner. Age is often assigned as the cause of the trouble when in reality the parasite has done the work. It is surprising to note the great number of trees and vines killed in a single season in the province of Naples alone by *Dematophora*. Fig and mulberry trees seem especially liable to its attacks, although cherry and pear trees are almost equally susceptible, and the trees whether old or young are killed.[1]

The effect of *Dematophora necatrix* upon *Vitis vinifera* was carefully studied during the time spent in the vineyards about Naples. It is exceedingly common among the extensive vineyards on the north slope of the range of mountains forming the backbone of the Sorrentine Peninsula and reaching out toward Nocera. It is also common in the vicinity of Vesuvius. It was found on vine roots from Portici, and what were probably its effects were seen at Torre del Graco, Pompeii, and Scafati. At the last two places it had killed fig trees of large size growing along the Sarno River. At Angri beyond Scafati vines were studied which had been dead some time, others which had just succumbed, and still others in all stages of disease from the infested but large and thrifty vine to that which had been cut back little by little until only a small bushy top remained on a stock 4 or 5 inches in diam-

[1] I have seen many fig trees a foot or more in diameter, and which had borne many years, entirely dead from its action. Other trees full of fruit and only a few years old were suddenly stripped of all their foliage, owing to the action of *Dematophora* on the roots. Pears have been seen which were in their prime when killed, and dead young mulberry trees were seen in several instances. Vines in Sicily are also affected by this parasite, and at Syracuse I saw a very large fig tree that had been recently killed. A cherry tree at Angri, more than a foot in diameter, was killed by it, and the man in charge had no knowledge of the cause. The disclosure of a fungus working in the roots and underneath the bark was a revelation to him.

eter, and which in health would have covered 400 to 600 square feet if grown after the system there adopted. By observation of this disease at various places its action independent of most other vine diseases has been learned. This has enabled me to appreciate its importance and bearing when combined with several parasitic diseases, and to largely refer to each disease the effects which were due to its action. The preceding remarks refer to the action of parasitic diseases on the top of the vine in distinction to the action of *Dematophora* on the roots. The distinction between the effects of *Dematophora* and other root parasites is not here considered, and is much more difficult to define.

Like the vine infested with Phylloxera, that suffering from *Dematophora* is gradually reduced in its top growth. If the stock be grown high and the runners are long, one division after another will die and be removed by pruning, until the top of what was a wide-spreading vine is reduced to the size of a bushel basket. The main canes have shortened internodes, and their direction is more apt to be changed at each node than in a healthy vine. This gives a peculiar, irregular, and angular appearance to the growth, and it is similar to the scraggy growth of almost any stunted tree or shrub. From these main canes arise great numbers of lateral ones, which are most numerous toward the base of the parent cane. These secondary canes present a wiry appearance. They are short and angular, and have their nodes approximated. The leaves at the extremity of the primary and many on the secondary canes are much reduced in size. One feature of the foliage resembles that of Phylloxera infested vines. The spring leaves are comparatively large, and the smaller leaves of the secondary growth mingled with them give the top a very uneven and unsightly appearance. The usual beautiful harmony of healthful vine growth is transformed into a most unsymmetrical and unkempt appearance. In this respect *Dematophora* causes a much more unsightly appearance than the California vine disease. The proper proportions of leaf to cane are much better maintained in the latter disease than in the former, where the leaves are sometimes quite minute. There is also a decided difference in manner of growth. In California the canes do not send out a large number of short and wiry secondary shoots, as do the vines infested by *Dematophora*. The bushy appearance of the diseased vines in California is due to the short growth of the main canes and to the system of pruning. The bushy appearance of *Dematophora*-infested vines is largely due, on the other hand, to the superabundance of secondary canes, originating near the stock.

In *Dematophora*, the colors of the leaf are usually normal, or but slightly altered. On a large vine seen at Angri, which had been cut back until only a bushy top remained little larger than 3 feet in diameter, I failed to find any foliage showing the characteristically arranged dead tissue so commonly seen in California. On a nearly dead vine observed at Portici some of the foliage had a yellowish appearance,

showing constitutional weakness,[1] but there was no death of tissue between the veins, although the color was lightened, approaching a chloritic condition. This retention of chlorophyll by the leaves at once distinguishes this disease from those allied to the disease of California. Another important feature of the leaves which distinguishes the action of *Dematophora* from that of the California disease is that when the vine dies the leaves remain attached to the drooping canes. The top, which has been gradually reduced to a minimum, wilts with the leaves upon it, and the latter dry as they would upon a cane which had been cut off and thrown upon the ground, yet retain their position upon the cane to its very extremity. It seems, though this requires further observation, as if the terminal and newer leaves were less apt to fall than the basal and more matured ones. None of these dried leaves showed any decay of the parenchyma between the veins, so common on diseased leaves in California. These are all important distinctive characters. In California the cane is usually bare before the death of the vine, one of the most important signs of the disease being the premature fall of the leaves.

The effects of *Dematophora* just considered, viz, (1) the short bushy lateral growth; (2) the normal green of the foliage when the vine is diseased; (3) the retention of the leaves until after the death of the vine, point strongly to some other class of diseases than those grouped under the head of parasitic root diseases as the true cause of the California malady.

Mr. J. de Barth Shorb believes that the evidence derived from a study of the diseased vines points toward the leaf or the cane as the seat of the trouble. This has also been quite largely indicated by my own observations in the field. The entire stock, however, eventually seems to be involved. It should also be noticed that observations on European vines attacked by *Dematophora* tend to strengthen rather than to weaken the evidence of this field work. The evidence in California points toward the upper portions of the vine as the parts first affected, while the parasitic root diseases of Europe do not produce the effects noted in California.

The habits and appearance of *Dematophora necatrix* can be but briefly mentioned. Like Phylloxera, *Dematophora* develops more readily in the more compact soils, soils of a sandy nature being less infested. On the vine it may at first attack only a portion of the root system, but it eventually reaches all of the roots, and the vine then rapidly dies.

There are several ways in which it is distributed. In cultures growing in an earthen pot the mycelium spread laterally through the earth

[1] Prof. Viala says that at first the leaves remain green, but they are much smaller than in the normal condition, and may be only from 2 to 4 centimeters in diameter; they are deeply serrate, and sometimes very much cut; they grow yellow but rarely, and then only in the last stages of disease. At this time the very short, partly dried shoots, like hairs collected in tufts, yellow and drooping, give the branch the form of a cabbage head. (*Les Maladies de la Vigne*, p. 337.)

for several inches until it reached the sides of the jar, over which it expanded like a thin sheet of cotton. It also penetrated to the bottom of the jar and passed out through the central opening into the earth beyond. Thus the roots of the vine are reached, and new vines are infested in the immediate vicinity. As the fungus is a saprophyte as well as a true parasite, the mycelium readily finds in bits of wood and bark material for food in its passage from plant to plant. Small slips of wood placed at the side of the culture jar were at once attacked. A second means of distribution is through the transfer of particles of mycelium from place to place by mechanical means. To ascertain whether new inoculations may be made by the mycelium alone, a series of cultures upon grape roots were started by the transfer of bits of mycelium. Although this experiment is still incomplete, it has gone far enough to warrant me in saying that the fungus may be transferred from plant to plant when a considerable portion of a rhizomorpha is taken. It follows, therefore, that soil cultivation must aid materially in distributing the disease. A third means of distribution is by means of spores, which are produced in abundance under certain conditions. In the vineyard the usual progress of the disease is from a center, as in case of Phylloxera.

Considerable moisture is necessary for the successful development of *Dematophora*. Hence the best treatment known for the disease is the removal of the affected stocks and a thorough stirring and drying of the soil. It should be turned often to a considerable depth, and all parts exposed as much as possible to the sun and air. The object of this is to unfit the soil for the growth of the fungus and to kill as much of the mycelium as possible. During these processes all scraps of wood, no matter of what kind, should be carefully removed from the ground. The wet places should also be thoroughly drained.

There are several forms of mycelial hyphæ belonging to *Dematophora*. On the exterior of roots, where favorable conditions exist for rapid growth, the mycelium presents a tufted expanse or a dense mass of snow-white hyphæ, the whole extending along and winding about the root like a band of white wool or silk. The growing extremity of the band is often more expanded than the portion just behind it because of the separation of the hyphæ at the end of the band. By this silk or wool-like growth the eye is able to determine the presence of the fungus. The hyphæ of *Dematophora* have, in some cases, a characteristic structure. This is the enlargement of the hypha at points where septa occur into pear-shaped swellings, the hypha continuing on from the abruptly contracted end of this enlargement being of normal size. In other cases only slight constrictions are seen near the septa. The hyphæ are white and brown, the white ones being formed first. These white hyphæ are of two sizes, the larger arising from the smaller. The pear-shaped swellings sometimes occur in the larger filaments, but not in the smaller. These smaller hyphæ are the active vegetative portion of the fungus, while the larger white ones may be considered

as semiprotective. The brown hyphæ are on an average larger than the white, and a larger percentage of them bear the pyriform swellings. The walls of the brown hyphæ are more distinct, and their cells do not generally show the granular contents sometimes present in the white hyphæ. A root-like strand of mycelium, known as a rhizomorpha, is formed by a combination of brown and white hyphæ, the former being mostly external and protective. These root-like strands form blackish brown and irregular strips upon the exterior of affected roots, and are also found passing through the soil. A portion of one of these transferred to a new substratum will continue to grow, and will inoculate the new host. At points where the finer white hyphæ emerge from the strand they present a glistening white, silky appearance.

The spores are produced in large numbers from the terminal filaments of an erect compound sporophore. These filaments branch in such a manner as to form a bushy head. The head is white and the rest of the sporophore is dark. The hyphæ are distinctly septate, usually several in number, and they often arise from a sclerotium-like body at the surface of the host. Several sporophores may arise from a single base, and this basal support is formed of a tissue of hyphæ arising from the mycelium within the host.

Dematophora has been found in several places in the United States, but whether the American form is one of the two species found in Europe is doubtful. So far as known, this fungus has not yet been found in southern California. The climate is unfavorable to its growth, but it could exist in the moister valleys and cañons and might do a limited amount of harm. After once obtaining entrance into the interior of vine roots or cuttings it will retain life without water for many months, even when the roots or canes are removed from the ground. This has been observed in material brought from Europe.

AGARICUS MELLEUS Linn.

This fungus is of nearly equal importance with *Dematophora necatrix*. It is an active parasite in vine roots in all parts of Europe, and has been reported from northern California. Thus far I have not observed it in the southern part of the State. Among those who have studied the fungus are Robert Hartig, A. Millardet, Brefeld, and Foëx and Viala. Millardet held *Agaricus* accountable for the greater part of the Pourridié of the vine, but Foëx and Viala incline to the view that *Dematophora* is the more general cause of the rotting.[1] There has been no

[1] F. von Thümen's views on the nature of Pourridié in which he claims *Fibrillaria* as the cause, appear too indefinite to be accepted when they stand opposed to the careful and complete work of Hartig, and of such practical observers as Millardet, Foëx, Viala, and others. *Fibrillaria* is no longer held as the cause of Pourridié of the vine; on the other hand it is held by prominent workers to be purely saprophytic. There is evidence in von Thümen's writings that the effects of one fungus are confounded with the presence of another.

opportunity for a personal study of the effects of *Agaricus* upon the vine, but the necessary facts for comparing it with the California disease may be drawn from the observations of Millardet, made among the vines at Lavardac, Lot-et-Garonne, southeast of Bordeaux.

The vine usually bears an exceptionally large quantity of fruit the first year of attack, and lives from two to three years. The leaves are reduced in size, but retain their normal green color. This agrees with what has been said concerning vines suffering from *Dematophora*, and is largely true for vines infested with Phylloxera. The effect in the vineyard is much like that of Phylloxera, although the spread is less rapid. The affected spot enlarges from the original center of infection in all directions or in a more or less irregular manner. Vines planted near forests or on recently cleared ground are more likely to be attacked than those in airy situations and in long-cultivated ground. Moisture is an aid to the development of *Agaricus* as with *Dematophora*, and the top of the diseased vine likewise presents a bush-like appearance.

Upon the roots, instead of the white, silk-like bands of *Dematophora* are root-like cords of mycelium which serve much the same purpose. The hyphæ of these cords do not show the characteristic pyriform swellings of the brown hyphæ of *Dematophora necatrix*. There are, however, as in that species two general kinds of mycelia; one fine and vegetative in function, the other compact and protective, and serving for the immediate spread of the fungus. The former penetrates all parts of the tissues of the host, and by it the life of the fungus is maintained. Near to and at the surface of the affected root the finer mycelial filaments are found in bundles, more and more protected by a sheath as the exposure becomes greater. On the surface of the root the cords are composed of a bundle of fine white hyphæ, surrounded by a perfect sheath of dark brown pseudoparenchyma, which becomes thin at the growing tip of the cords. These dark-colored round cords run through the earth or about the diseased root, passing into and among the irregularities of the bark, and at once distinguish *Agaricus* from *Dematophora*.

The spore-bearing body of *Agaricus melleus* is an edible mushroom 3 to 5 inches high and with a pileus or cap 4 to 6 inches in diameter. The velum ruptures as the agaric grows older, forming an uneven collar about the stalk somewhat below the cap. This is figured by Hartig.[1] The white stipe enlarges toward the base, the swelling being well marked in the younger stages, and bears minute villous papillæ. The cap is somewhat conical above and yellowish in color, the shade darkening with age. The edge is slightly fringed, and minute scaly spots of a brownish color are found on the upper surface. The gills are white, spotted with reddish brown. The mushroom rises from the ground directly from the cord-like strands, or from the infested plant close to the surface of the ground. It is often found in large clusters.

[1] Lehrbuch der Baumkrankheiten. Berlin, 1889, p. 181, fig. 107.

GRAPHIUM sp.?

While working on diseased vine roots in the Santa Ana Valley a species of fungus was found very generally infesting roots obtained from many places. This form has been placed in the genus *Graphium* Corda. Although it was very common, in fact so common that many diseased roots were black with its spores, I do not think it can be considered as the cause of the death of the vines. It was carefully studied, however, and a large number of sections of vine roots were made and examined. In one or two instances the mycelium was seen penetrating the cortical parenchyma of the root at a point some little distance above the badly decayed parts, and a considerable number of hyphæ were seen branching and growing in this tissue. It was noticed that these hyphæ were growing outward toward the epidermis. It seems probable they had penetrated to this semidiseased portion of the root by means of the xylem vessels and were passing outward from these, as similar hyphæ were distinctly seen within and crossing the vessels. It has been mentioned elsewhere that owing to the wet rot of the cortical parenchyma the epidermis of the rotting root may be easily stripped from the fibro-vascular bundles. It is a coincidence, though perhaps only such, that the present species of *Graphium* lives and fruits almost wholly within this portion of the root. The mycelium is quite common in the decaying parts, but less common in the semihealthy tissues. After most of the softer tissues of the root are decayed away the fungus begins to form spores, and the conidia cover the woody bundles so thickly that the latter become black. The sporophore is composed of a large number of parallel or interwoven hyphæ, which form a firm stalk. These hyphæ separate at the top of the stalk and each produces at its extremity a single conidium. The crown of spores on the stalk usually takes a form somewhat like that of *Graphium stilboideum* Corda, but the hyphæ mostly remain erect with the terminal spore, not turning down on all sides as in that species.[1] By retaining this erect position they often give almost a flat summit to the conidia-bearing stalk of hyphæ, with the exception of the spores, like the slightly expanded end of a round paint brush. The compound sporophores arise either from the wood bundles and bear conidia just under the epidermis of the root, or they arise from the inner side of the dry epidermis and produce their conidia next the wood bundles. In either case the fruiting is within the epidermis of the root, and is rarely if ever found outside. The spores are oval, entirely distinct in form from those of *G. stilboideum*, and usually when mature contain two round, clear spots, one toward each end of the conidium. The immature conidium very often has but a single spot. The walls are thick and fuscous in color, like the walls of the supporting hyphæ. Efforts to induce germination of these spores in the fall of 1889 were unsuccessful, though various

[1] See *Saccardo F. Ital.*, tab. 14.

nutrient solutions were tried. It is probable they require a period of rest.

No detailed description of this form will be given here, as further study may develop new facts of interest in its life history. At present it seems to be mainly saprophytic, although there is little doubt that its action in the cortical parenchyma of the vine roots hastens their early decay to some extent. The question as to whether it may live as a parasite after decay has been incited by some other means, requires still further observation to establish or refute. I do not think it can be shown that this *Graphium* bears any relation to the cause of the disease.

VIBRISSEA HYPOGÆA Thümen and Passerini.

I have found this fungus in the Santa Ana Valley on the roots of vines which had been brought from Missouri, but not on any *Vitis vinifera* stock of the dying vineyards. It is doubtful whether the form is ever a true parasite, though its saprophytic habits are well known. As it has never been fully shown to be the cause of the death of the vines it infests, it is unnecessary to consider it here. Its effect on the host should have further study from the standpoint of vegetable pathology, as at present authorities are divided as to its action.

FUNGI ATTACKING THE FOLIAGE, FRUIT, AND CANE.

DOWNY MILDEW (*Peronospora viticola* D'By.).

When the death of the vines began to be general in southern California and the disease seemed to be spreading from a center at Anaheim, some vine-growers, unfamiliar with the appearance and action of *Peronospora*, advanced the idea that this fungus was causing the loss. To one familiar with the action of *Peronospora* it required but a moment's examination of the diseased vines to determine that this was not present and bore no relation whatever to the trouble. Although this active parasite is known to exist at several places toward the northern portion of the State, I have yet to learn of its occurrence south of the San Bernardino Mountains. It is not impossible that it exists there, and search among the wild vines of the moist mountain cañons may yet reveal it. If it does not exist in this region it is presumably owing to the presence of the vast arid plains surrounding it at the east and north, and to the long, dry summers which there prevail. It is a fungus requiring moisture for its successful growth and spread. From observations on the habits of the parasite in many parts of Europe and northwestern Africa, where its effects were noted on *V. vinifera* stock, the prospect in southern California in case of its introduction may be to some extent foreshadowed. In such event its permanent habitat would be the foothill cañons where springs abound and along the banks of constantly flowing streams. In these situations it would ob-

tain a permanent home upon the native vines. Its subpermanent habitat would be on the artesian grounds and in the more moist and humid valleys. From the subpermanent region the drier and more elevated regions would be infected in wet seasons. In Italy districts analogous to these subpermanent regions have been diseased for years without general damage being done in the district. At Rome *Peronospora*, according to Prof. Cuboni, was introduced about the year 1880, and did not develop during the following ten years so as to do much damage to the vine-growing region about La Colonna. In 1890, however, the fungus developed rapidly and the vineyards about Rome became badly infested.

I was much interested in the methods adopted at Rome and carried out under the supervision of Prof. Cuboni for the instruction of the peasants in the treatment of vine and other plant diseases. A gentleman is there appointed to go from place to place in the country, visit vineyards, and hold meetings where lectures are given explaining the presence and habits of the injurious fungi; and he gives instructions as to the best methods of treatment for the prevention and cure of the diseases caused by them. I had the pleasure of meeting one of these instructors in the vineyards about La Colonna, where he had come to join Prof. Cuboni and his assistant in their fieldwork. It was learned from him that his work often met with indifference and opposition, and the enlightenment of some of the peasants was by no means a desirable occupation, keeping him employed from early morning till late at night. The butt of a revolver, which peeped out from beneath his coat, spoke volumes as to the situation and for his persuasive power, and it paved the way, on our trip back toward Rome, to the recital of some interesting experiences.

The vines are grown according to a very distinct system at Rome from those systems commonly practiced about Naples. The Roman system of cultivation is one rarely seen elsewhere than near Rome. In the low spots, where the moisture of the soil is abundant, cane is planted and grown thickly. This cane is used in the vineyards as stakes for the vines. Instead of growing the vines low, as at Bordeaux, and running the cane in a horizontal manner, the vines are grown high, 6 to 9 feet, and are trained to a point in the form of a cone by being supported by canes stuck in the ground in such a manner as to form a framework like that of an Indian hut or wigwam. The vine runs up these canes on all sides of the cone to the apex, thus inclosing a space like a miniature wigwam. The fruit will hang in the shade. Beyond the rather attractive appearance of a vineyard thus trained and the shading of the fruit, I can see little to commend in the system. Hand labor is required in cultivation; the vines are more apt to be injured by mildew than when more open to the air. The labor of staking and training the vines is great, and the space devoted to the growth of the cane for support might be to a great extent, in my opinion, more profitably

devoted to some other crop. It is fair to say, however, that there may be advantages in yield or quality of output of which I am not informed.

Between Rome and Naples various systems of training the vine are in use, but few vineyards are grown as in California. For some distance south of Rome the vines are grown as at La Colonna and Frascati, but in some cases upon single canes, much as pole beans are grown in the United States. In other places on the way to Naples the vines are in rows far enough apart to render cultivation possible one way by horse. This is rather the exception than the rule. Hand work certainly largely predominates there, and nearly all methods of staking are used.

The plain or country of Naples furnished a sight to one interested in viticulture which probably can not be elsewhere seen. In the vicinity of Cancello, about 14 miles northeast of Naples, the system of vine culture is one of the most beautiful I have seen. Much of the soil there is ash-colored, fine, loose, and productive. It resembles the *pozzolana*, the famed volcanic earth or ashes used in making mortar, and found in such quantity at Pozzuoli. Over this plain are set lines of trees, usually poplar. In some of the best and oldest vineyards these trees are in rows 70 feet distant from each other and 35 feet apart in the row. Over some portions of the Neapolitan plain these trees have attained a large size, the average in one vineyard being about 14 inches. The tops are cut back at a height of from 40 to 45 feet, thus preventing the shading of the ground to an injurious extent, preventing the trees from breaking, and furnishing fuel for the peasants. About the base of these trees are planted a number of vines. In one vineyard the vines had attained considerable size, varying in diameter from one-half inch to 5 or 6 inches, according to age. From 3 to 8 vines are grown next each tree. The stocks spring from the ground separately. The vines climb freely, running out and hanging from the limbs. As soon as canes are of sufficient length upon adjoining trees in the row they are brought together so as to form a loop. This loop is kept about 10 feet from the ground, and above it may occur a second, a third, and sometimes a fourth, each 3 or 4 feet above the one below. In time these looping vines become large and loaded with hanging canes and fruit, and where three or four loops occur the entire space between the trees above 10 feet is curtained with the most beautiful festooning foliage, and for great distances is one continuous green wall. The trees themselves are covered by vines to a height of 20 to 25 feet. The fruit is rather undersized and not overabundant. There are some advantages for this system, but these advantages are not such as will induce the adoption of a like system in our own country. The main advantage is the saving of ground for the cultivation of other crops. Between these trees are grown flax, corn, beans, etc.

Vines grown upon trees are more free from diseases than those grown upon cane or poles as at Rome, on account of the free circulation of air

among the former. On the other hand, it is difficult to treat vines grown according to the tree system with the various fungicides.

About Rome and Naples the vines have been comparatively exempt from the bad effects of *Peronospora* for several years. In 1889 it became very injurious in the province of Naples, and in the vicinity of Nola the crop was then almost wholly destroyed. In 1890 I had an opportunity of observing the effects of the disease under a great variety of conditions, and found a very large percentage of loss due to *Peronospora* in some sections. In the valleys between Rome and Naples the loss due to this fungus would in some cases reach two-thirds of the crop. East of Naples, in the valleys back of Sarno, and as far as Avellino, serious work of destruction was progressing. Some of the vineyards near Avellino had been treated with the Bordeaux mixture. Along the mountain range south of Scafati, following the southern border of the plain of Naples, few vines were treated and much fruit was lost in 1890. West of Naples and back of Pozzuoli many vines are grown on the hillsides, and it was evident there that elevation tended strongly to give exemption from the disease. The vines in the more elevated situations were but slightly affected. The great vines near Cancello, also, where the distance between the trees upon which they are trained is great, were not nearly as badly infested as vines more closely cultivated.

The effect of a dry climate upon the growth of *Peronospora* was distinctly shown by passing from Naples to Sicily, and along the eastern coast of the latter country. In the province of Naples nearly all vineyards were badly infested, but in Sicily a search for many days over much of the vine region on the eastern slope of Etna failed to show a trace of the fungus. A center of infection was at last found north of Giarre, in a vineyard where a moist spot not more than 200 feet in diameter occurred. After the fall rains began other infested vines were found in the same locality. All that was required to infect all the vineyards of the valley was suitable temperature and sufficient humidity. Further south along the coast of Sicily the region is dryer, rains about Etna being much more frequent and heavier than they are at Syracuse and Noto, and as a result *Peronospora* was scarce.

Through the valley and mountain regions bordering the Mediterranean coast of Algeria to a width of 50 to 100 miles the humidity is greater than in southern California. The mountains are green and vegetation grows well without irrigation. Here again *Peronospora* was doing serious work in the vineyards. But the methods of treatment used in France have been adopted. The fungus is much more capable of doing serious work in Algeria than it would be in southern California, the conditions in Sicily being nearer what might exist in that State. One vineyard on low ground in the department of Constantine, Algeria, had been cut back to the stumps on account of the injuries from *Peronospora*. The vines in nearly all parts of the country are suffering to some extent, though they are in better condition than many vines near

Naples, owing to the superior care given them and the more open system of cultivation.

The effects of *Peronospora* show some characters which are similar and several which are dissimilar to those of the California disease. The greatest similarity to the latter is shown in the premature fall of the leaves and the consequent unripened condition of the canes at the approach of the dormant season. The local effects of this fungus, whether on cane or leaf, can not be confounded with those of the California malady. Hundreds of observations were made on *V. vinifera* stock diseased by *Peronospora* for the purpose of ascertaining if in any case this fungus will so weaken a vine as to induce the death of the foliage with the peculiar markings observed in California, without the direct and localized action of the parasite; but such has not been found. The foliage is either directly destroyed by the fungus or the tissue which dies as a secondary result of its parasitism dies as if it were sunburned or destroyed by the approach of cold weather.

Peronospora viticola is so exceedingly common over most of the eastern United States that few persons interested in grape-culture are to be found there who are not familiar with its appearance and habits. Therefore space need be taken here only for a short general description intended as an aid in recognizing the fungus for the use of persons not familiar with it. The canes, leaf, and fruit may all be attacked. On *V. vinifera* the leaf is first and most seriously injured. The vegetative portion or mycelium invades the region of the leaf parenchyma, its branches or hyphæ running between the cells and throwing out short branches called haustoria at various points along their course. These organs pass through the wall of the adjoining leaf cells and develop into small spherical bodies within the cell cavity, where they retain their connection with the mycelium and act as absorbent or feeding organs. Two kinds of propagating bodies or spores are formed by this fungus: (1) Conidia or nonsexual summer spores, for the rapid increase and spread of the fungus; (2) oöspores or sexual winter spores, which have thick walls and preserve the fungus through the winter and infect vines in the spring. The summer spores are borne in great numbers on the branching ends of erect hyphæ which protrude from the stomata on the under surface of the leaf. The vast number of these hyphæ, which are called conidiophores, gives to the affected part of the leaf the appearance of being covered with a white down. This has given rise to the term Downy Mildew. The oval summer spores, under favorable conditions of humidity and temperature, may spread the disease with remarkable rapidity. The reason why this fungus requires moisture should be known by all vine-growers, that they may understand the true action of the chemicals used in the treatment of this disease. These spores are almost wholly dependent upon a certain amount of moisture for their successful germination. When dew or rain has wet the leaf bearing these conidia the protoplasm with which they are filled breaks up

in an irregular manner into four to twelve smaller portions. The end wall of the conidium bursts open and these minute masses of protoplasm pass rapidly out into the water upon the leaf.

These jelly-like spores are now known as zoöspores, from the fact that they swim about in the water, much as some of the lower animals, by means of two cilia attached to each of the spores. Water is therefore required for the distribution of the spores over the leaf. But the wide-spread distribution over the vineyard is probably mostly accomplished through the action of the wind. The zoöspores, which are minute atoms of protoplasm without a cellulose wall, are very easily destroyed by fungicides. The salts of copper contained in the Bordeaux mixture are sufficient to kill all of them if dissolved in minute quantities in the water where the spores exist. The spores being killed the spread of the fungus is checked. If no fungicide be used the zoöspores distribute themselves over the surface of the leaf, where in a short time they become round and secrete a cellulose wall about themselves, having first shaken off the two cilia which served for locomotion. These spores now grow like other spores, sending out a germ tube, which enters the leaf and reproduces the fungus. The second form of spore, the oöspore or winter spore, is formed within the tissue of the host, where it remains over winter. As this spore can not be easily reached by fungicides during its formation, the details of its development will not be given. At the time of its germination it can be controlled by fungicides in the same way as the conidia.

POWDERY MILDEW.

There is still some doubt as to whether the powdery mildew of America is identical with the Oïdium of the vine in Europe. The American form, of which the summer and winter spores are well known, is *Uncinula spiralis* B. & C. The European form, the life history of which has not yet been fully made out, should be known as *Oïdium Tuckeri* Bky. It is unfortunate that the name Mildew is used in California for this fungus, while *Mildiou* is applied to *Peronospora viticola* in France. This has given rise to some confusion in the past and constantly leaves one in doubt as to what fungus is intended where both exist. For this reason it is best to speak of powdery mildew when referring to *Uncinula*. Many Californians have already adopted the European name *Oïdium*, and this is preferable to the word mildew alone. It would be better however, to use the generic name *Uncinula*, which is that of our American form, until the full life history of the European fungus is made known.

Powdery mildew, according to John S. Hittell, was known in northern California at least as early as 1859. Mr. H. H. Roper, of Santa Ana, says that prior to 1861 *Uncinula spiralis* had sometimes destroyed one-third of the crop in a vineyard owned by him at Santa Clara. In 1861 he tried the sulphur treatment. Certain rows in the vineyard

were treated and others untreated. The favorable results obtained from the former vines established the system of treatment there.

The fungus appears to have traveled south through the State.[1] It was present in southern California in the earlier part of the sixties. Mr. A. Langenberger, one of the oldest residents of Anaheim, says[2] that as near as he can recall the facts *Uncinula spiralis* first badly attacked the vines at Anaheim in 1868, which was a very wet year. He says he saw a little of the fungus for several years earlier, but the only serious damage done, so far as his observations extended, was in 1868. Powdery mildew has been present in the vicinity of San Diego for many years. If it was introduced into California in 1859, which is doubtful, its spread over the State was probably accomplished in from one to three years.

In accordance with general usage, *Oïdium Tuckeri* will be considered in this bulletin as identical with *Uncinula spiralis*. When *Oïdium* spread over Europe, after its appearance on the Rothschild vines in 1847, it was known as "*the vine disease.*" By 1851, as Prof. Viala tells us,[3] the vineyards of France, Italy, Greece, Spain, Hungary, Switzerland, Asia Minor, and Algeria were all infested. Since then it has done much harm in all the vine-growing regions of Europe, and has only been kept in check by the liberal use of fungicides. Indeed, the effects of the fungus are so serious that as good authorities as Prof. Millardet and De Grasset are of the opinion that if the vines in the department of Hérault, France, were left unsulphured for two years, the crop of grapes would be ruined. Nevertheless it seems to be rare for a vine to be killed by this fungus, even if of the less resistant varieties. The vines are affected by *Oïdium* all over Europe, but no widespread death due to its action is found upon the continent.

The vineyards which have died in California have been badly affected by *Uncinula spiralis*. It is present everywhere, and its favorite season of development is the same as that when most injury is done by the malady under consideration. Heat is one of the more important requirements for the injurious growth of the fungus. Humidity is of rather less importance, as *Uncinula* will thrive on the dry and arid mesas of southern California where *Peronospora* would perish. The coast regions however, where heat and humidity are combined, are most seriously affected. These facts hold true for the vine disease of California as well as for *Uncinula*. On the other hand the markings on the foliage shown in Plates XII, XXI–XXIV, are quite general and very

[1] Prof. Gustav Eisen, of Fresno, stated in 1889 that at Fresno the vines had only been sulphured since about 1881, and at first only along the rivers. After this the fungus spread to the dryer and higher vineyards and sulphuring became necessary there. At first vines under 4 years old were nearly exempt from its effects, but at present young and old vines are both injured. All vineyards are now sulphured.

[2] Letter of January 16, 1891.

[3] Les Maladies de la Vigne, Paris, 1887, p. 11.

characteristic of the California disease, while they do not generally occur on vines attacked by *Uncinula* or *Oïdium* elsewhere than in California. Prior to 1884 vines did not die from the effects of *Uncinula* in southern California, certainly not in any considerable numbers, although this fungus had existed there for nearly or quite twenty years. *Uncinula* is found at present in all parts of the State, yet the vines are not dying, nor are the leaves of vines generally marked in other parts of the State as in southern California. A careful examination of the effects of *Oïdium* on *Vitis vinifera* in the vineyards of the Old World for the purpose of learning the effect of this fungus on that stock when epidemic, or when the attacked vines had been neglected, failed to show any evidence that *Oïdium* can produce either directly or indirectly the appearance of the foliage characterizing the disease of California. Such observations point toward one of two or three conclusions, viz, either (1) the *Uncinula* of California and *Oïdium Tuckeri* are distinct, and the former is more capable of injuring *V. vinifera* than the latter; (2) the relation of *Uncinula* to the disease is secondary to that of some other disease-producing agent; or (3) local conditions are now or have recently been such as to enable this fungus to produce effects not resulting from its action elsewhere. Of the first condition it may be said that the *Uncinula* of California appears identical with that of the East, although its identity with *Oïdium Tuckeri* is not fully established. These questions remain open for further investigation.

Uncinula spiralis is too common in California to require more than a passing description. Early in the growing season it sometimes affects the flower, causing it to fall. The fruit, therefore, does not set, and there is a consequent loss in yield. At the approach of hot weather the vine is attacked upon the growing parts, the canes, leaves and petioles, and fruit all being more or less affected. Unlike *Peronospora*, *Uncinula* has its vegetative organs or mycelium on the surface of its host. The haustoria or absorbent organs penetrate only the epidermal cells, where they expand in an irregular manner. Two kinds of spores are formed, and both are produced upon the surface of the leaf or other parts affected. They may be known as (1) conidia or nonsexual summer spores, serving for the rapid increase and spread of the fungus; (2) ascospores or sexual winter spores, serving to preserve the fungus through the winter and to infect vines the following spring.

It is strange that the perithecia of *Oïdium Tuckeri* have not long since been found in Europe. It has seemed that the climatic conditions there are such that their development is not required or that the action of the host plant on the fungus was different. De Bary, in speaking of the group of fungi to which *Oïdium* belongs, says:[1]

> Every thallus which proceeds from the germination of either conidia or ascospores ends, when it has reached its full development, with the production of archicarps and antheridia, that is, of sporocarps. But it need not always arrive at this conclu-

[1] Morphology and biology of the fungi, etc., p. 225.

sion, but may only form conidia and propagate itself by means of them through an unlimited number of generations. This imperfect development may usually be traced to obvious external causes, such as climatic conditions or the absence of the nutrient substance required for perfect development; that is, the proper species of phanerogam. The *Erysiphe* [*Oïdium*] of the grape vine is the best example of the group. From the circumstances attending its first appearance and its diffusion in Europe it may be safely assumed that it suddenly migrated and was transferred to our vines from some other species of phanerogam. It most probably came from America. In spite of its destructive diffusion over the whole of vine-growing Europe the most careful examination has never detected any sign of a sporocarp: the invasion was entirely carried out by vast numbers of conidia, the shape of which procured the plant the name of *Oïdium* (*O. Tuckeri* Brk.). The sporocarps are probably found in North America on native species of *Vitis*, and described as *Erysiphe* (*Uncinula*) *spiralis* Brk. & Curt., but this is not certain.

Thus De Bary explains the absence of perithecia or sporocarps of this fungus in Europe as due to the influence of climate or absence of host. It certainly is not true that mild winters are sufficient to induce an unfruitful habit in this fungus, for abundant supplies of perithecia are found in southern California, where the winters are far milder than they are in most parts of Europe where *Oïdium* exists. The vines upon which these perithecia developed were *Vitis vinifera* stock and the Berger variety. They were abundant on this variety near Orange and Pomona. Well-developed examples were also received from south of Fresno, on leaves of the Muscat. In view of these facts the explanation of the incomplete development of *Oïdium Tuckeri* in Europe, if *Oïdium Tuckeri* and *Uncinula spiralis* are the same, is a desideratum.

From the mycelial filaments spreading over the surface of the host there arise large numbers of erect hyphæ which produce terminal conidia, *i. e.*, the spores are cut off by a transverse cell wall and separate one after the other from the extremity of each hypha. Several of these spores may usually be seen like a row of beads at the end of a hypha. These conidia will germinate under conditions of much less humidity than is required for the germination of the conidia of *Peronospora*. They germinate directly and the parent spore sends out a germ tube which grows into a mycelium. The mycelium thus arising sends the haustoria into the epidermal host cells and the summer history and rapid reproduction of the fungus is complete. In case of *Uncinula* the winter spore is also formed. It is produced at the approach of the dormant season of the vine. These ascospores are contained, when mature, to the number of eight within thin-walled asci; and these asci, again, are contained within thick-walled and protective perithecia, in numbers ranging from four to eight. The formation of these sexual spores is directly from the mycelium. The main fact to be noted is that these bodies as they are upon the surface of the host, both during their early and more tender stages of formation and after being fully matured, are as accessible to fungicides during their formation as are the conidia produced during the summer.

Californians find the sulphur treatment quite satisfactory, so far as

the fruit is concerned, for checking the injurious effects of *Uncinula*. The vine-grower's attention is fixed upon the condition of the berry, rather than the condition of the vine as a whole. This feature of the matter should be seriously considered. The effort of the grower should not alone be to save the fruit in a perfect condition, but treatment should be made with the view of keeping the vine in a thriving and healthy state. The vines of one of the most intelligent vine-growers in the vicinity of Bordeaux, France, were carefully examined to learn the sulphur treatment to which they had been subjected. Every leaf of the vine was powdered with sulphur. Throwing a handful of sulphur upon the ground under a vine will do much to save a crop of fruit, but the tender terminal shoots still curl from the *Uncinula*. Some persons in the region of Bordeaux consider it of as much importance to combat *Oïdium* as Phylloxera and *Peronospora*. This is, however, upon the looser soils, where Phylloxera is most easily kept in check.

ANTHRACNOSE (*Sphaceloma ampelinum* D'By.).

This fungous disease is not as yet known in southern California, though it is common in much of the eastern United States and in Europe. It could not easily be confounded with the prevailing disease were it present. Fruit, foliage, and canes are alike attacked by it, and the effect upon the different portions of the vine is quite variable. In some cases its action upon the fruit seems of most importance; in other cases the canes and leaves are most affected. The disease is readily known by the canker-like marks produced on the host. The attacked vines do not die in a general way, and it is the exception to find a considerable region with all, or nearly all, the vines affected. In Italy it is at least most common to find it developed in a sporadic manner. Here and there a vine or group of vines are affected; then, perhaps, no trace of it will be seen for some distance through the vineyard, when another infected spot is encountered. On the large vines in the province of Naples it is quite common to find but one portion of a vine attacked. That the disease may be known by those unfamiliar with it in California, a few notes on its general effect on the vine will be given.

The spots first affected, whether upon the cane, leaf, or fruit, are very small and of a dark color. Upon the canes the spots enlarge and show a black border about a white center. These spots are often of considerable size, according to the size of the cane; often becoming 4 to 10 millimeters in transverse diameter. As this spot enlarges it becomes somewhat elongated, spreading more readily with the grain of the wood than across it.

As the destruction of the tissue progresses outward the central portion becomes depressed and opens longitudinally. This canker-like spot passes not only through the bark but deep into the wood, and the destruction of tissue progresses deeper at the medullary rays than elsewhere. Before the split occurs, the white center fills the entire space

within the black border, but as the canker deepens the center grows darker, though the white coating may dip into the depressions. The canker may involve nearly the entire shoot at the point attacked, causing the latter to become weak and brittle. Often two or three cankers form a circle around a cane. The cane may be attacked at any place, either upon the node or internode. If the cane be young the terminal growth is more easily destroyed. The ultimate effects of the disease are sometimes very disastrous. A vine at Duvivier, Algeria, had been attacked with such severity that the canes were eaten and pitted with black on all sides from the extremity to the body of the vine. It looked as if each individual branch had been burned deeply in spots so close together that scarcely a particle of healthy tissue remained. The only possible remedy in such a severe case would be to cut the vine back close to the ground.

The leaves may also be attacked at any place. The petiole is often attacked, and the destruction of the blade is soon accomplished by cutting off the sap. On the blade the spots may be located in the parenchyma or along the veins. The larger spots on the leaf are generally bordered by a fine black line, within which the tissue is usually dead and brown, sometimes having a slight whitish cast. The leaf parenchyma covered by the spot is at first entire. Later, the dead central portion breaks across, and when the spot becomes somewhat extended the irregular opening is often quite large. Usually the leaves are affected in a great number of places. Over thirty spots were counted on one small *V. vinifera* leaf, and more than twice that number may be easily found on leaves of even less diameter. It is noticeable that where the veins are affected the spots are more apt to be elongated than upon the leaf parenchyma, where they are nearly round. The same reason assigned for the lengthening of the spots upon the cane will apply here.

The fruit cluster of *V. vinifera* is affected in much the same way as the cane and leaf. The peduncle is often attacked, frequently in several places. The diseased spots have a black margin and the usual whitish center. The berry is attacked at any part, but perhaps most often at the flower end, a fact which may be due to the more ready retention of spores at that point. So far as personal observation extends the facts show that the berry of the native American vines is more affected by this disease than that of the *Vitis vinifera* varieties, and that the canes and leaves of the *vinifera* varieties are injured more than those of the American varieties. On the *vinifera* berry the point of attack is often flattened and retarded in growth, causing the berry to grow one sided. This distortion will sometimes cause a berry to turn to one side in its growth rather than to grow directly forward from its peduncle. The same result may arise from the attack of the fungus upon the peduncle.

The mycelium of *Sphaceloma ampelinum* D'By., forms below the epi-

dermal tissue of the cane or fruit, but when about to produce its conidial spores the epidermis of the host is ruptured by the pressure of the mycelium beneath it. From this mycelium there arise great numbers of erect hyphæ, forming a whitish mat at the surface of the affected parts, and cut off immense numbers of conidia from their free ends. Sections through diseased spots show, at the margins, minute pustules where the epidermis is being raised by the hyphæ. These pustules increase in numbers and become more pronounced toward the center of the spot. The hyphæ which pass to the exterior through ruptured places in the epidermis become more numerous till a continous layer is often found at the center. The spores are elongate oval, mostly binucleate, and vary much in size and somewhat in form. The ravages of this fungus, though known for a long period in France, were exceedingly severe there after the season of 1877.

A comparison of this description with that of the California disease will reveal the dissimilarity between the two. Anthracnose exists at Angri, Italy, in vineyards and sometimes on vines showing the peculiar markings of foliage seen in California, but this was not always the case, and there is clearly no relation between the two. The peculiar markings may occur without Anthracnose, and Anthracnose without any such peculiar markings of foliage. Anthracnose occurs in the vineyard of the Royal High School of Agriculture, at Portici, Italy, where it affects *vinifera* stock. In some cases here both canes and leaves were badly attacked, but in no case observed have leaves been found discolored in any way resembling a constitutional trouble. No markings were seen on the foliage like those in California. Some slight yellowish markings were found, but nothing at all approaching the deep and distinct discoloration of foliage due to the California disease. The leaf or cane may be attacked and eaten off, and still no such markings result. It can then be said that this fungus disease, though sometimes very severe would not be capable of alone producing the effects seen in the California disease. Mr. George Husmann, of Napa, in his new edition of American Grape Growing and Wine Making, New York, 1888, pp. 267–268, says:

> Of diseases we do not suffer very much here, although mildew (*Oïdium*), black knot, red leaf—also called Spanish measles, which is the same disease, I think, called Anthracnose in France and "Pocken des Weinstocks" in Germany—and Coulure, or imperfect setting of the young fruit prevail to a certain extent.

Further he says:

> *Red leaf or Spanish measles.*—This will prove identical, I think, with the disease the French call *Anthracnose*. It generally appears in midsummer, when the fruit is but half grown. The leaves of the vines show red spots, finally become red altogether, and drop off. The young fruit becomes discolored, first grayish, then shrivels up and turns black. Very often only a certain branch of the vine is affected, while all others are healthy; a vine may have it one summer and be entirely free from it the next. It is most destructive on the Mission grape, although it attacks all varieties more or less. It has never been very destructive as yet. An application of sulphate of iron in solution is recommended as a remedy, applied in spring; some also recommend sulphur, but I can see no benefit from the latter.

The term Spanish measles is here used in California for a disease resembling Rougeot, so far as the description goes. Anthracnose is not a disease to be mistaken for the simple reddening of the foliage as seen in California. An examination of the leaves affected for some time by Anthracnose will show the openings through the tissue due to fungous action, and the cracking is not seen on leaves affected by Rougeot, or the "Red leaf" or "Spanish measles" of California.

BLACK ROT (*Læstadia Bidwellii* (Ellis), V. and R.).

Black rot has not yet been reported from California. Its effects upon *vinifera* stock could in no case be confounded with the effects of the disease in California, either in a special or in a general way. About the only feature of similarity between the two is the dried and wrinkled appearance of the fruit. In case of black rot, however, the berry becomes black and shows the perithecia, pycnidia, and spermogonia, as minute elevations of its surface. The berry dried under the action of the California disease does not turn black and presents no roughness of surface due to spore formation. It is like a dried grape for the market, or one somewhat sunburned. Foliage affected by black rot distinctly shows the location and action of the fungus in the form of round brown spots on the tissue.

Black rot is another of the fungous diseases depending largely on an abundant supply of moisture for its successful development. This makes it probable that no great amount of injury will be done in southern California by this disease if it is ever introduced. In some of the more confined and humid valleys where grapes are grown is where its worst effects would be felt.

CLADOSPORIUM VITICOLUM Cesati.

This fungus is not found generally over southern California. Thus far it has been found in the vicinity of Norwalk, where it was very general in one vineyard; also in the vicinity of Los Angeles and at Garden Grove. It is an active parasite and capable of working serious injury to the leaves of the vine.

The vineyard above mentioned was the Charbono variety, and badly diseased.[1] Its effects upon the leaf resemble in some respects those of the black rot fungus, *Phyllosticta labruscæ* Thümen. The spots are mostly round, and usually quite sharply defined and distinct. When they run together they form irregular patches of dead tissue. They are not generally as large as spots formed by Anthracnose, and the dead tissue does not break as readily as under the action of that disease. About the spots is often a well-defined narrow ring, which is blackish in the dried leaf and inclined to red in the living tissue. The fruiting hyphæ are clustered near the center of the dead tissue on the

[1] See Plate VII, Bulletin No. 2, Section of Vegetable Pathology, U. S. Department of Agriculture, 1886.

under side of the leaf, where they appear as minute black specks or spines. This is unlike the arrangement of the black conceptacles of *Phyllosticta labruscæ*, which are scattered more irregularly over the dead tissue of the leaf. This fungus has been seen in Europe many times, usually in moist situations, but the injuries it produces are usually of secondary importance as compared with those caused by *Oïdium*, *Peronospora*, etc. It is very common about Milazzo, Giarre, and Catania, Sicily.

Probably the spread of this parasite in the moist regions where it thrives in California could be checked by a judicious use of the Bordeaux mixture. So far as known *Cladosporium viticolum* is incapable of producing any general death of the vine foliage through great constitutional weakness of the stock due to its parasitism. It is not known to kill vines; and its marks upon the leaf never assume the forms which characterize the California disease.

SEPTOSPORIUM HETEROSPORIUM Ell. & Gall.

This is a fungus common in southern California in the more moist situations, but is thus far only known on the leaves of native vines. It was first found by Profs. Viala and Scribner, on October 14, 1887, while visiting the wild vines of the Santiago Cañon northeast of Orange. At the time of its discovery it was supposed to be *Septosporium Fuckelii* Thümen, but a microscopical examination soon showed that it was a distinct species, and it received the name of *Septosporium heterosporium* Ellis and Galloway. The form is a true parasite and of much interest,[1] and has been compared with *Septosporium Fuckelii* Thümen. From this it is, however, quite different. This fungus has been collected at several places along the course of the Santa Ana River, and I am inclined to believe that were it introduced into the Southern States, or should unusual moisture allow it to spread beyond the river bottoms in California, it would cause much loss to vine-growers. It ruins the leaves of the wild vines in damp and shady situations. There is probably little danger of its spreading in southern California, as it is only found in the cooler and more moist situations of its native habitat. It assuredly bears no relation to the present disease, and its appearance is easily recognized and wholly distinct. No evidence of a constitutional trouble arising from it has been observed, and no dead vines due to its action were seen.

ANIMAL PARASITIC DISEASES.

MITES AND NEMATODES.

Within the decaying roots of diseased vines a Nematode worm and a mite are quite commonly found. The Nematode has evidently only a

[1] See figure on Plate XIII of the Report of the Section of Vegetable Pathology, U. S. Department of Agriculture, for 1888.

habitat in the decaying wood. It does not produce any gall or swelling of the roots, as is true of the Gulf State species, and certainly has no important bearing on the present disease. Nematodes were quite commonly found in the vine roots in the vicinity of Naples, but these forms produced galls, and there is no doubt that they injure the vines they infest.

The mite which is found in the decaying vine roots is of more interest. It frequently occupies a position next the newly decayed tissue of the root, and follows the line of decay as it progresses upward. All stages of this mite are found in the roots, and from the habits of allied forms, as well as from the common location and abundance of these Acarids, they seem to take a more or less active part in the destruction of the cortical parenchyma of the roots. It is, however, not probable that they have more than a secondary relation to the disease.

PHYLLOXERA VASTATRIX Planchon.

Although well known east of the Rocky Mountains, and a decided pest in Europe, this destructive insect is not found on the dying vines of southern California, and it is not, therefore, necessary to consider it, except from a comparative standpoint. It is desirable to consider it in this way, however, as much light may be thrown on the nature of the present trouble from the action of the different diseases upon the vine. My opportunities of observing the effects of Phylloxera on *Vitis vinifera* have been quite extended, as regions have been visited where its advent is recent and also where many years have passed since its introduction. Its action has been noted on many varieties of vine, grown on all classes of soil. Below Bordeaux the "oil spots" were found, and there and at Faro, Sicily, the gradual destruction of the vines from center to circumference of these spots was noted. In company with Prof. A. Aloi I visited and carefully inspected the Phylloxera-infested vineyards over many miles of the vine-covered plains west and southwest of Catania. Again, through the valleys west and south of Syracuse, and near Milazzo on the north shore of the island, the effects on various soils have been seen, the loose and sandy soils being most favorable to the preservation of the vine. The situation in southern France was of deep interest, as here we have the outcome of the earliest efforts to combat the insect and the results from years of experience in various systems of treatment. There also are the remnants of the vineyards which existed before the new system of vine-growing on American stocks was introduced. With the California disease always in mind, I have observed all the varied conditions arising from the presence of Phylloxera in these European vineyards.

The short growth and bushy appearance of affected vines in some cases recalls the short growth seen in the Santa Ana Valley. It also resembles the effects produced by *Dematophora necatrix*. But the top of a vine infested with Phylloxera may become reduced in size and still

remain covered by nearly normal green foliage. After Phylloxera has passed like a blight over a region, as it did at Faro, above Messina, where the insect was first observed in Sicily, the vines may be found on the loose sand at the seashore and upon the slopes and tops of the hills in all stages of decay. Several careful examinations were made of the roots, which were shriveled and dry, and all conditions were found, from the "oil spot" on the sandy bottom to the dying and scattered vines on the hard soil of the hillside. This examination was made during the heat of the season, when fruit and foliage taxed the vine to the utmost, but in no case did I see any death of the leaf which could be confounded with that on dying vines in California. Near Bordeaux an affected spot was observed in a vineyard having as yet a complete stand, which appeared as if it had been pruned much shorter than the adjoining or surrounding unaffected portions of the vineyard. The difference in height was due to the poor growth of the affected vines. The border of the affected place could easily be followed with the eye. At that time (June 11) the color of the foliage was nearly normal. The "oil spots" occur anywhere in a vineyard where infection has taken place. The dissimilarity of action on the foliage to that observed in California was also noted at Pauillac, in the Médoc; and this holds true of the infested vineyards of Napa and Sonoma, Cal. The action of Phylloxera, when shown by the leaf at all, is rather that noted on a sunburned leaf or that common in the general death of the tissue in the fall. There may be a lighter color in some cases, showing general weakness of the stock. Death of the parenchyma, as shown on the Flaming Tokay leaves (Pl. xxii) or those from Angri, Italy, or Folletage from Sicily, does not follow the attacks of Phylloxera. One character is similar—the sap is deficient in both cases. Vines affected by Phylloxera may be known by the dryness of the wood when pruned. A French pruner acquainted with the dryness of Phylloxera vines was able to foretell in California the death of a vineyard by the feeling of the cane. This was observed while pruning affected vineyards in the Santa Ana Valley. So far as my examination of Phylloxera infested roots has gone, there is more moisture found in the decaying roots of southern California than in most roots decaying from the effects of this insect. On vines trained rather high, although the main canes of spring growth are often long and the leaves upon them are of normal size, the lateral canes are quite short and the leaves much reduced in size, giving the whole vine a bushy appearance. The growth of the extremity of the main canes is also stunted late in the season, the short terminal internodes resembling those of the lateral canes.

The attention of vine-growers in southern California should be called to the danger in which they now stand. Many persons who have lost their *vinifera* stock are turning their attention in a small way to varieties of the vine from east of the mountains. This, it is true, is not being extensively done, but the danger is almost as great. Rooted

vines are brought to the various cities and set out as arbor plants, or they are taken to the ranches in limited numbers. It should be understood, if not already known, that Phylloxera is found in nearly all parts of the eastern United States, and that indiscriminate introduction of eastern vines will almost assuredly bring this pest into the *vinifera* vineyards of southern California. No one should be allowed to bring rooted vines from the east into this region. Where a plant may be easily reproduced from cuttings, and these cuttings so easily disinfected, there appears no necessity for running the great risk of admitting rooted vines. The same precaution should be adopted respecting vines from the Phylloxera-infested regions of northern California. The danger is especially imminent at the present time when all are looking to the setting of new vineyards. The ability to irrigate the land should never be regarded as a safeguard, and resistant stock is very far from satisfactory in many fine vine-growing regions. If the scale insects which are visible are worthy of the efforts being made to suppress them, then Phylloxera, which is hidden and more difficult to combat, is equally worthy of united efforts for its exclusion.

ERINOSE (*Phytoptus vitis*).

This disease is common in southern California as it is in nearly all portions of the world where vines grow. The main object in mentioning it here is to show the difference between its effects and those of *Peronospora*, for which it is often mistaken. Erinose is a leaf gall produced through the action of a mite known as *Phytoptus vitis*. These mites mostly work on the under side of the leaves, and their effect is to cause the formation of a gall or elevated spot in the parenchyma. This enlargement usually projects upward, the under surface of the leaf presenting a concavity. In this concavity the mites work, and the irritation of the leaf induces an abnormal growth of the epidermal hairs of the under side of the affected part.

This lengthening and distortion of the leaf hairs gives a downy appearance to the under surface where the galls occur, which closely resembles the effect produced by the growth of the conidiophores of *Peronospora*. The wild vines in a cañon near San Gabriel were badly infested with this mite, and I have found it near Los Angeles, where in some instances vine-growers were alarmed over its rapid spread. Its effects are not serious, being a matter of unsightliness more than anything else. Sulphur or a weak solution of carbolic acid are recommended for use against it. It is usually allowed, however, to take its course.

WHITE ANTS (*Termes*).

The white ant belongs to the family Termitidæ. Three genera of this Neuropterous family are found in California, viz, *Calotermes*, *Termopsis*, and *Termes*. Members of the last genus are particularly destruc-

tive in the vineyards in the southern part of the State. They will attack comparatively young vines, but do the most damage in the old vineyards, especially among vines of the Mission variety. Entrance to the wood is usually obtained through the pith, which is in many cases entirely eaten away. In old vines they mine into the wood, until little more than a honeycombed shell remains, and the vines may be broken off even with the ground or kicked into fragments with little effort. At Santa Ana vines of the Muscat variety were eaten, and at San Bernardino an old Mission vineyard was badly infested. The almost limitless fecundity of the insect should make it an object of lively interest to vine-growers, for if not checked they are capable of doing much injury in the older vineyards. They have already become a decided pest to orange growers in Florida, where it is not an uncommon thing to find newly set trees girdled by them.

Mr. J. E. Chase, formerly of Lakeville, Fla., informs me that these insects are known in Florida as "wood lice," and that they will kill a tree by girdling it just under the surface of the ground. He says they certainly attack and kill orange trees when small,[1] and says further:

> I saw a tree 4 feet high, about 1 inch in diameter, turning yellow last summer. I dug about its roots just below the surface of the earth, and it was covered with white ones [larvæ], and they had girdled the tree so that it died. * * * I have just replaced three orange trees that were killed by them last summer.[2]

This Florida species is the common *Termes flavipes*.

Dr. H. A. Hagen[3] gives the following species as inhabiting California:

Calotermes castaneous (Burm.). San Francisco.
C. marginipennis (Latr.). San Francisco and San Diego.
Termopsis angusticollis Hag. San Francisco.

To this list I will add the description of a species of Termes from San Bernardino, not yet fully determined. I also have a form from Santa Ana.[4]

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[1] Dr. Erwin F. Smith states that the same is true in Georgia respecting plum trees in nursery rows.

[2] Letter of February 9, 1887.

[3] Synopsis of North American Neuroptera, Washington, 1861.

[4] Genus Termes: Head large, rounded, two ocelli; prothorax heart-shaped, small; costal area free; plantula absent.

Termes sp?

Winged imago: Dorsum of head and thorax light chestnut, often a black, dorso-median line on meso and meta nota; dorsum of abdomen fuscous; head flattened above, with an indentation between the eyes; pronotum semicircular, marginate; venter of head, thorax, and abdomen lighter; eyes black; ocelli close above the eyes, not more than one-fourth the diameter of the same, whitish; sides of mouth parts (base of mandibles) dark brown; antennæ usually 16 to 18 jointed, first and third joints longer and darker than the others; legs tawny yellowish; tibia with spurs; wings roughened, smoky, darker along the costal margin. From recent alcoholic material.

Length to tip of wings 11 to 13^{mm}. Body 6 to 8^{mm}. Alar expanse 18 to 20^{mm}.

Nympha; Active, whitish, wing-pads reaching to end of third abdominal segment;

Over much of Europe *Termes lucifugus* occupies the position of our *Termes flavipes*. In the province of Naples it is quite a pest in the older vineyards.

In Sicily is a form, probably the same, which is exceedingly destructive to the old vineyards located on Etna. It is working in the interior of the vines wholly without the knowledge of the vine-grower. Vines were badly infested and many could have been easily broken off. The action on the stock is very injurious, as the insect mines near the base, where it cuts off the flow of sap and causes early death or a much weakened condition of the top. The general effect is much like the rotting of the trunk near the ground.

NONPARASITIC DISEASES.

CHLOROSIS.

This disorder of the vine is not considered due to the action of parasites, but to unfavorable physiological conditions. Just how these unfavorable conditions produce their effect is doubtful, but the results are clearly manifest and are capable of definition.[1] In France, at Montpellier and Bordeaux, it is held by scientists and those familiar with viticulture that an excessively calcareous soil or subsoil is among the more prominent causes of this disorder. The appearance of a chlorotic vine is entirely different from one affected by the California disease. The leaves begin to assume a yellow hue, passing by degrees through all stages from the normal green to a light yellow, sometimes becoming almost white. On vines having this disease, examined west of Montpellier, the entire leaves, with the exception of a few portions, were involved in the chlorotic condition. The veins were almost invariably involved in the discoloration, which sufficiently separates chlorosis from the effects of the California disease, since these always remain green in the latter. Where any distinction of color is observed between that of the veins and the adjoining parenchyma it is not uncommon in chlorosis to find the veins lighter in color. Cases have been seen where the venation

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eyes distinct, black; a lateral dark spot before the eyes on base of mandibles; antennæ whitish, about 16 to 18 jointed; an indentation on the head between the eyes; pronotum semicircular, narrower than the head, immarginate. Length 6 to 8mm.

Larva: Active, whitish; eye spots just discernible, reddish; other reddish spots laterally before the antennæ; antennæ 12 to 16 jointed, the third joint dividing; pronotum narrow, collar-like. Length 5 to 6mm.

Habitat: San Bernardino, Cal. September 23, 1889.

For observations of interest see, especially, American Naturalist, vol. 10, pp. 401–410; also Proc. Boston Soc. Nat. Hist., vol. 20, Dec. 18, 1878, pp. 121–124; and various notes in INSECT LIFE.

[1] The experiments of Sachs (The Physiology of Plants, pp. 284–286), showing the absence of chlorophyll in chlorotic plants and its reproduction upon the addition of the soluble salts of iron to the food supply, or its introduction artificially into the chlorotic plant itself, are of interest in this connection.

was outlined in yellow on the normal green of the leaf. Besides the leaves the young shoots, as well as the spikes of unopened flowers or flower clusters, become yellow. This alteration of chlorophyll and general debilitated condition of the vine results in a shortened and stunted growth of the cane. On large vines observed in the province of Naples I found one branch only of a vine showing chlorosis, and in other cases much of the vine was involved. Chlorosis may cause the death of the vine. The stock becomes weaker each year and at last the roots and leaves dry and the stock dies. The evidence that chlorosis arises from physiological or constitutional causes is good.

Chlorosis is not a common trouble in southern California, although it occasionally occurs in limited areas. In the department of Hérault, in France, it is a serious trouble, and very extended tracts of vines are affected. It is much more common there than about Bordeaux. Between Montpellier and Cette the vines show much yellow foliage. South of Cette they look better. Toward Béziers they are again somewhat affected, and the soil has a whiter and more calcareous appearance. At Moux many of the vineyards have a decided yellow cast. Below Bordeaux chlorosis is met with at Ludon and a few other places, but at Pauillac in Médoc, where there is one vast vineyard for miles, there is no indication of a chlorotic condition. The Médoc soils are quite different from those of much of the department of Hérault, and they are peculiarly adapted to the healthful growth of the vine. It is a mixture of a large amount of gravel with a rich, black, sandy loam. There are variations in the amount of sandy loam and gravel, and in some places it is replaced by a heavier, black or reddish loam. This soil becomes less common as Bordeaux is approached, while at the same time the vines show less vigor and vitality. The mingling of a uniform-sized gravel with a loose, rich, black loam of the nature here seen is not of common occurrence. The country about Pauillac is so rolling that the soil is warmer than that of the adjoining more level regions. There is, with one exception, no grape region known to me like this in the United States, and which will produce the *Vitis vinifera* varieties. This exception is found in the rolling, black, sandy, and gravelly loam lying back of the town of Encinitas, San Diego County. I confidently predict for that region a future which will far surpass in quality of fruit, under proper methods of cultivation, any other region in California which I have seen. In this region there is a close approach to the soil conditions of the Médoc. This is not a mere resemblance, for the matter has already been tested on a small scale, and the finest grapes of any I have seen were there produced, and no irrigation was practiced.

The order and perfection of cultivation of the Pauillac vineyards surpass description. It is no wonder that they have gained their present reputation when to the advantages of location are added those of

perfect methods of training and cultivation.[1] The soil is easily cultivated, owing to its sandy nature. In many places immense beds of gravel underlie these vineyards. Drains of tile are usually found at the foot of slopes, or they run through the drives which cross the vineyards at short distances from each other. Openings are made into these drains, and they are furnished with grates as in a street; and the surplus surface water escapes in this way without making cuts among the vines or carrying the rich hillside soil to lower levels.

The contrast between these vineyards on rich, sandy soil and those on the calcareous soils of the Hérault is very marked. Chlorosis, as already said, is common in the latter region, but it is almost unknown at Pauillac. The part taken by the soil in causing chlorosis is strongly brought out by thus comparing these two leading vine-growing sections of southern France.

Variety has also much to do with chlorosis of the vine. Some deeply interesting investigations on this subject have been made by Millardet and De Grasset at their experimental grounds north of Montblanc, between Pézenas and Béziers. They have been able to obtain all degrees of resistance to chlorosis by means of hybrid vines. This is also true respecting several other diseases of the vine, and their work should have the careful attention of California vine-growers.

POURRITURE.

Pourriture of vine roots is a decay of the roots owing to unfavorable surroundings, such as an overabundance of moisture and other injurious conditions of soil and subsoil, or is the result of a weakened or diseased state of the entire plant. The term is used in France to express the above conditions in distinction to the term Pourridié, which signifies root rot due to local parasites.

The decay of vine roots prevailing in California, so far as at present known, falls under the head of Pourriture. The cause has not been shown to be of a local parasitic nature. Viala states[2] that the indirect action of *Peronospora*, Anthracnose, or *Oïdium* is sufficient to induce Pourriture of the vine roots. The rotting of the roots, it is thus seen, is not evidence that they are the primary seat of the disease. Anything having sufficient influence on the vine to induce the premature fall of the leaves must act strongly upon the root system, and the loss of the leaves and death of canes must also involve the drying, death, and final decay of many of the smaller roots. Speculations upon the inciting cause of the existing Pourriture need not be entered into here, as they involve

[1] As an illustration of the care given these vines I will state that in one small spot in a vast extent of vines the soil was heavier than elsewhere in the vineyard. Here sand had been drawn and the place was made uniform with the rest of the vineyard. This may have been on account of Phylloxera.

[2] Les Maladies de la Vigne, p. 437.

such subjects as moisture, soil, temperature, parasites, etc., which have been treated of separately under appropriate headings.

MAL NERO, ROUGEOT, AND FOLLETAGE.

For the purpose of this bulletin it is unnecessary to enter into a discussion of the disputed questions which have arisen in regard to Mal Nero. It will be sufficient to note the points of resemblance or dissimilarity between the vines affected by what the Italians call Mal Nero and those dying in California of the prevailing disease.

MAL NERO IN ITALY.

Mal Nero has been studied by Italian botanists for the past twelve or fifteen years, and has been observed in Sicily since 1869 at least. In northeastern Sicily the dying vines first attracted attention. They were observed about Milo, Giarre, and Riposto, on the east slope of Etna, in 1877, in considerable numbers. Since that date many explanations have been offered to what seemed to be the same disease in various provinces over much of Italy. The effects of several diseases on the vine are confounded in some instances, and investigators have found it difficult to assign any fixed external characters to the dying vine which could not be shown to arise from other causes. As a consequence the study of the pathological histology of the plant itself has been taken up, the alterations of the tissues and cell contents being considered a better ground for characterizing the disease. But here again we are at a loss to define and characterize the disease, if indeed such it be. The cell contents are altered; but whether the brown masses found within the cells are gum or tannin, and whether the condition in which it is found is the result of normal physiological processes or is due to some inciting agent such as bacteria, are questions equally open to discussion. The *thylles* of the vessels were apparently not at first recognized as normal formations;[1] and whether the minute spherical bodies observed within them by Garavaglio and Cataneo were bacteria or normal granules has not been satisfactorily demonstrated. It seems probable that the characterization of Mal Nero by means of the brown bodies found in the cells of the wood, due to the alteration of the cell contents, and the discoloration of the wood itself, is wholly insufficient to separate this disease from effects produced on the vine under several known conditions.

In 1889 Drs. E. Casoria and L. Savastano published the results of investigations concerning the nature of Mal Nero of the oak.[2] Their conclusions are of interest here. They found that parts of the oak having most tannin, as in early stages of development, became blackened most quickly when exposed to oxygen, and that those parts most ex-

[1] Cugini recognized them in 1886.

[2] Il Mal Nero e la tannificazione delle querce. Studio dei dottori E. Casoria e L. Savastano, presentato dal Socio Tomassi-Crudeli, 1889.

posed to air or water blacken quickest. The immature wood or fruit blackens more quickly than that matured. Cavities made in the acorn cause intense blackening if made before the acorn arrives at maturity, but at maturity the color is not so marked. Wounding always induces more or less decided blackening, according to the tissue. In dissection of the affected tissues the same phenomenon is always found; the protoplasm is coagulated and blackened and the cell wall is more intensely black. In woody tissue the vessels blacken first. The authors have repeatedly shown that the blackening was in the region of tannin. Tannin extracted from the timber (quercitannic acid) blackens after a short exposure to the air, at first, however, turning an intense violet color. This phenomenon is common to all the tannins and is due to rapid oxidation. Gum from the oak is, when it first exudes, of a simple transparent yellow color; subsequently it becomes opaque and blackish. The investigators conclude that as they observe the phenomenon of blackening in different diseases and woundings of the same plant, it can not be characteristic of any special disease. As all the elaborated principles and the protoplasm degenerate under pathological influences, so one of them, tannin, degenerates; and this degeneration takes place in a way similar to that of a solution of tannin exposed to the air. An attempt has been made to determine whether the blackening is due to degeneration apart from the tannin, or if there is a combination of the tannin with the cell wall and dead protoplasm.

The attempts made at an analysis of the blackened cell walls have always resulted in finding the black unalterable, and from this fact they suppose there is a combination. A proof of their conclusions upon the nature of Mal Nero is found in the two following facts: Blackening of tissue is not found in the oak in the process of rotting. The phenomenon of blackening is present in certain diseases of oaks, walnuts, chestnuts, and vines; the fig, olive, mulberry, drupaceous and citrous fruits do not show it. The former are plants containing much, the latter containing very little, tannin. It is concluded that if in different diseases of the same plant the identical phenomenon is repeated, and if in different plants in the same pathological condition the same phenomenon is not constantly found, it must be inferred that it is not characteristic of a disease, and certainly not of the particular plant in which it presents itself. It is due to the very apparent degeneration of an elaborated principle, tannin, which degenerates as the protoplasm, other elaborated principles, and cell walls degenerate under the influence of a pathological process. On this account the authors hold that the names Mal Nero, Nerume, and Tannose, indicating a special pathological process as held by pathologists, as they understand, should be abolished.

While in southern California, grape wood was received from Portici, Italy, affected by Mal Nero. This was carefully compared histologically with wood from affected vines in California. The same apparent alterations of cell contents appeared in both cases. Until a careful

comparative study of wood of vines dying from known causes, such as the entrance of water into closely pruned spurs, those dying from great age, or from the effects of Folletage, etc., has been made, it appears unsafe to say that the presence of the altered cell contents, such as are seen in vines said to have been affected by Mal Nero, or the discoloration of the wood there noted, is sufficient to distinguish this trouble from all others. The appearances seen in Mal Nero are what may frequently be found in vines, and are in no way confined to Italy. They are especially common where the inner parts of the wood have been exposed to the action of air or water. This was often noticed in California. The central parts of the vine are quite apt to become thus altered and discolored where the pith of pruned canes admits, by its decay, of the ready oxidation of the surrounding parts. A cane left green by the premature fall of the leaves will sometimes turn black, much as wood is affected by Mal Nero. R. Dezeimeris has shown that the stock of a vine may be injured by improper pruning, and that the wood, after the entrance of water, will assume the black hue and general appearance of vines said to be affected by Mal Nero.[1]

The following characterization of Mal Nero is that given by Targioni-Tozzetti.[2] He says the effect upon the vine is—

> A decay with blackening of the walls of the organs and different parts which compose the wood of the vines, associated with a deposit of brown granular material on the inner surface of the walls; natural change of the mature wood, but not that in actual formation; invading here and there at different heights and depths the stock of the vines, spreading from part to part, and manifested by chlorosis of the leaves, by imperfect growth of the fruit; followed by the decay of the branch or of the trunk where it occurs.

In describing Mal Nero it has often been stated that the blackening of the wood occurs at the side of the stock in the form of a triangle, the apex being toward the center of the vine. My own observations make me believe this character has no distinctive worth. The form assumed by the discolored wood is evidently due to the natural arrangement of the rays, which in the vines are quite continuous from pith to cambium and much diverging outward, and also to the proportionately large and continuous vessels. If a cane be affected by Folletage or Rougeot the vessels of the body of the vine which are in functional relation to those of the injured cane are the ones affected by the injury, and these vessels will transmit any disordered state of the cell contents longitudinally in the trunk much more rapidly than laterally. It is for this reason, I think, that the discoloration is found limited to triangular zones. Again, if the injury arises below the altered wood the same may hold good by an upward flow of disorganized matter.

In Italy and Sicily several prominent laboratories at the leading schools of agriculture were visited. In all cases I have been most courteously shown the materials and preparations relating to Mal Nero there preserved. I have also described the California disease to the botanists

[1] Dépérissement de la vigne. Bordeaux, 1889. Pl. I–IV.

[2] Annali di Agricoltura, 1884.

connected with these institutions and in no case have I met one who has ever seen a disease which developed in the same manner as that in California. Without exception, the botanists of both France and Italy who have been consulted have said that Mal Nero, as understood by them, has never appeared in any but a sporadic form, while the California disease completely destroys the vineyards.

Prior to visiting Europe and the laboratories of Bordeaux, Montpellier, Genoa, Pavia, Modena, Florence, Rome, Portici, Naples, Catania, and Palermo, the literature on the subject had been studied and the views of those who had written on Mal Nero had been ascertained. I learned that the disease designated as Mal Nero had caused greater loss in the vineyards of the provinces of Naples and Catania than elsewhere; and it was decided to make those provinces the seat of the greater portion of the fieldwork. Naples was reached on July 8, 1890, and I shortly afterward met Sig. Italo Giglioli, the director of the agricultural school at Portici, as well as Drs. Comes and Savastano and other gentlemen of this institution. I also had the pleasure of studying the material of Mal Nero in the possession of Dr. Comes in Naples. This material, of which I have specimens, was similar to that examined in the laboratories of Prof. Cugini, at Modena, and Drs. Briosi and Cavara at Pavia. As no vines affected in a similar manner were shown me in the vineyard, and as I was especially interested in the diseased vines in the field, I undertook an independent examination of the vineyards of the province. Three weeks were given to an examination of these in the eastern, northeastern, and western portions, before vines affected in any way similar to those in California were found.

Near the town of Angri, a few miles beyond Scafati, at the south side of the valley of the Sarno and on the slopes of the mountain range extending along the Sorrentine peninsula, some vines were at last found which bore foliage possessing the markings which characterize diseased vines in California. The likeness between these leaves and those on the diseased vines in California was so great as to demand careful attention. It was only after much careful consideration of the effects of the different parasites as observed elsewhere, combined with the study of these affected stocks, that it was possible to decide that this disease was certainly not due to the direct action of the known parasites present.[1]

[1] The conditions under which vines are grown along the base of the mountain chain are different from those found over the plain north of Vesuvius. About Angri they are mostly grown on perpendicular poles 6 to 10 feet high, and are looped from one pole to another, thus forming a somewhat dense growth. In many vineyards fruit trees are also grown on the same ground. Vines of all ages and sizes are found. As the canes are allowed to grow from year to year they acquire a considerable length and are trained horizontally, some 6 or 8 feet above the ground, thus leaving space for a man to pass beneath. In many cases other crops, such as beans, tomatoes, and corn, also occupy the ground, these crops furnishing the main food supply of the peasants in charge of the vines. It was on the long branches or runners of these vines that the leaves in many instances were colored as they are in California.

The leaves of the dark varieties of grapes show a red discoloration between the veins and at the margin. In the earlier stages this color is faint, but later on the tissue lying between the main veins becomes bright red, and still later dies and changes to dull brown. The death of the leaf usually begins at the margin, or in the center of the red stripes lying between the veins, or it may involve both regions at once. The venation of the leaf remains green in most instances, forming a symmetrical green vein system after nearly all the intervening tissue is dead, or has turned red or brown. Thus there are in these later stages three distinct gradations of color in the affected leaves: (1) A brown and more or less dried margin, or bands of brown lying between the main veins, or both; (2) a band of bright red bordering the dead brown portion of the leaf; (3) normal green tissues outlining the main venation of the leaf. All colors vary according to the time since the first alteration took place. The petiole is not involved at once in any evident change, but later the leaf is cut off. A second variety of grape had leaves altered in a somewhat similar manner to those of the dark varieties described, but the bright colors did not prevail. There was little to be seen of a third color on these leaves. The alteration is almost directly from the normal green to a dull muddy brown, as if the base colors were yellow and black. The dead tissue occurs first at the margin, and in spots and stripes between the main veins, rarely if ever touching a large vein. Between this dead tissue and the green next the veins is sometimes a slight transitional shade of yellow, which is nearly wanting in many cases, the brown being directly joined to the green on either side of the main veins. Where the intermediate yellow line is wanting the appearance of the leaf is very striking, and differs in color from any diseased varieties noticed in California. The pattern of the markings is, however, the same. The difference observable is a varietal one. The leaves of a variety of white grape were altered in the manner described for the Muscat of Alexandria in California. In the early stages the changes of the leaf are foreshadowed in faint yellowish spots in the parenchyma, which become more pronounced as the trouble advances. At this time the leaf may have a yellow speckled appearance. The spots are yet somewhat cloud-like and illy defined, and are rarely located upon a vein. As the discoloration becomes more marked these cloud-like spots are better defined at their margin and more and more of the parenchyma of the leaf between the veins becomes involved. As the light yellow spots enlarge the parenchyma at their center turns reddish brown and dies. Later there is a brown central stripe between the veins and at the margin of the leaf, and bordering this dead tissue is a line of half-dead yellow tissue lying next the green bordering the veins. All these markings are very distinct and well defined in the later stages of the trouble. As the death of tissue between the veins progresses it gives to the green bands at the veins the symmetrical appearance seen on the Muscat leaf in California.

On old wood the terminal portion of a long runner first bears spotted and striped leaves, and is the first portion to become bare. It is also the first to die if death ensues. When the attack is severe the vine continues to die back from the end, until, in some cases, the entire stock is killed, unless close pruning below the affected parts prevent the further progress of the disease. It is claimed it will do this in some instances.

On the new cane the spotting of the leaves progresses from the base toward the tip. Hence the end of the cane, where the fresher foliage is preserved, is green until the terminal leaves are dead. The order of death in new growth is: (1) Leaves dying from the base toward the tip of the cane; (2) cane dying from the tip toward the base. It is claimed that the vine often survives.

The foliage of the vine falls before the wood has properly ripened, and the latter remains immature and turns black. The blackening of the bark begins after the complete fall of the leaves and proceeds inward to the wood. This also occurs on old canes, the bark and cambium and often the wood turning black. The disease as shown by the death of the foliage, seems to pass downward toward the root. This is not, of course, proof that the disease is seated in the canes. The trunk of a vine will often crack open, forming deep checks through the bark and into the wood, and there is apparently a deficiency of sap. After the foliage falls the fruit remaining upon the vine dries, becoming shriveled like a raisin or dry wine grape. Plates XIII and XIV represent two stages of this disease. Plate XIII shows the spotted condition of the leaves, which may be termed the first stage, the tissue being almost entirely dead between the veins as far as the narrow green band of parenchyma through which the latter extend. The light line seen on the leaves corresponds to the red tissue between that which is wholly dead and the green portion. The leaves are of full size upon the vine. The internodes of the cane are also mostly of normal length. In these respects the growth does not resemble that seen on vines affected by Pourridié. A second and later stage of disease is that seen on plate XIV. In this the leaves have fallen and the bare canes are dying back, some of them being already broken but hanging to the vine.

On one old and badly diseased vine the terminal branches had been buried just behind their tips, for the purpose of renewing the stock. Vigorous canes 6 to 8 feet high had sprung from the tips of the old vine and many new roots had formed on the covered portions, sufficient under the circumstances to supply the new growth. But the leaves of this new growth were diseased, although there were no signs of a diseased condition in the roots, and the new growth was evidently relying upon them. The spots were general over the leaves, and a majority of them were rapidly dying. If a lack of sap was producing the diseased condition of the foliage of the parent stock, why were these leaves not normal beyond the new point of sap supply? Or, if the nourish-

ment from the new roots was appropriated by the entire plant, why had the new growth on the young vines been much greater, as was the case, than the new growth on the parent vine?

There seems to be no common name generally applied to the disease. Some of the peasants called it *Mal Rosso*, although this name does not seem to be applied in general. A gentleman in charge of one vineyard said he had noticed the disease for the past eight years; he also said that vines may recover from its effects. This position was held by others, although it was claimed that vines will sometimes die in from two to three years. The date at which the leaves begin to show their peculiar markings is said to be May and June. The date when first seen by myself was about July 28. It was then well developed and certainly must have been apparent a month or two earlier. The leaves begin to fall in the latter part of July, and many were falling on August 13. The vines do not lose all their leaves until later, being mostly bare by the last of September, and the cane is left in an unripened condition. On August 13 I saw an unripened cane blackened and dead. The fruit fails to mature and dries on the vine. I was told by the foreman of one vineyard that the roots rot one year later than the spots appear on the leaves. But this view, like that respecting the length of time before the death of the vine, needs to be taken with caution. It is said by the peasants that healthy shoots sometimes come up from near the ground, but it is not of common occurrence. I have not seen many such shoots, although there is evidence that the vitality of the vine is greatest near the ground. It was also said that these shoots are apparently healthy one year, but show disease the next. None of the peasants seem to have any idea of the cause of the trouble. There is certainly no defect of soil or subsoil, as all crops grow well upon the ground.

As *Dematophora necatrix* was present in this region it became necessary to distinguish between its effects and those above detailed. The following are among the characters used to separate the two diseases:

Dematophora.	*"Mal Rosso."*
(1) The leaves remain upon the vine after its death.	(1) The leaves fall long before the vine dies.
(2) The canes may wilt and droop, as with Folletage.	(2) The canes stand erect, as when denuded by *Peronospora*.
(3) The leaves are normal or nearly normal in color.	(3) The leaves are mostly spotted and striped, and often highly colored in red or yellow.
(4) The leaves are curled, and in many cases much reduced in size.	(4) The leaves are not curled, and mostly normal in size.
(5) The shoots are greatly increased in numbers, giving the appearance of a bush.	(5) The shoots are not increased in numbers, and the vine does not assume a marked bushy appearance.

The more direct way to determine the relation of *Dematophora* to this disease might seem to be to establish the presence or absence of the fungus on the affected vines. But no one who has not been in

Italian vineyards, and especially those about Naples, can have the faintest conception of the hopelessness of such an undertaking. Finding *Dematophora* on the roots of vines is not evidence of its causing this disease, any more than finding *Peronospora* on the leaves would show that to be the cause. It is possible, however, by knowing the effects of diseases when separate, to distinguish the effects of one disease from those of another when a complication of diseases exists. The recognition of the effects of the other known parasites present did not admit of much doubt or require so much study.

In the vineyards about Angri, where this trouble quite extensively prevailed, no approach to the condition in California was found. The diseased vines occur only in a sporadic manner, the greater portion of the vines showing no signs of the disease. In a vineyard of 3 or 4 acres perhaps ten or twenty vines are affected. The death of the vines when it occurs at all, is very gradual, and apparently severe pruning has saved some of them for several years. The disease is as sporadic as Folletage, but differs from it in that no part of the vine is at once killed. Although distinguishable in this particular, the appearance of the foliage is quite similar. No case was observed where any considerable number of vines were affected in one group, and no place exists to my knowledge where vines have died except in a sporadic manner. No cases of this disease were observed on the tree-trained vines near Cancello, although they were equally large and as old. The striking resemblance between this disease and the one in California, in relation to foliage, strongly indicates similar pathological conditions of the vine in some respects at least. The completeness of attack through the vineyard of the California disease and the certainty with which it kills the vines, indicates, however, that some element of disease is involved there not present or not active in Italy.

Some of the general views to which I have been led are the following:

(1) The disease appears oftenest upon old vines; (2) weakened vines are most affected; (3) there is evidence of a specific trouble; (4) in its action on the foliage and new growth it resembles the California disease; (5) no single observable influencing condition, such as severe pruning, defect of soil, or known parasites, appears to be constant; (6) the burden of evidence points to a pathologic condition of the fluids or elaborated material of the vine, or else to an obstructed condition, or, and which is more doubtful, to altered relations of its histological elements, or possibly to both.

This disease is evidently that described by Macchiati[1] as "Il Secchereccio della Vite." Leaves preserved in the laboratory of Prof. Cugini at Modena closely resembled those seen in California. They had the same yellow spots, and had they been gathered in California would

[1] Bollettino della R. Stazione Agraria di Modena, for 1889.

have at once been considered as affected by the California disease. I was informed that the Italian disease rarely kills the vine, and that commonly only a portion is affected. At Cugini's laboratory I was also shown leaves taken from vines which Prof. Cugini said had been affected by Mal Nero.[1] In some instances they somewhat resembled those of California, but this was not true in a majority of cases. In several instances the tissue was dead as far as the veins. At Rome, in Prof. Cuboni's laboratory, were leaves like those at Modena and Angri. Prof. Cuboni said that at Rome vines affected in this manner do not die.

As the affection at Angri was the only one of the province resembling in its effects those noted in California, it was desirable to obtain the views of Prof. Comes respecting its nature and effects as observed by him during many years of study in the vicinity of Naples. We visited many vineyards together, and examined a large number of diseased vines. Prof. Comes at once said that the affection I had been at work upon was his Mal Nero. This statement was repeated many times during our examination of the falling and highly colored foliage. In no case were the affected vines bearing the spotted leaves identified by him in any other way than as altered by Mal Nero. The various other diseases present were examined and discussed.

After having given the entire subject very careful consideration, I do not feel fully convinced that the characters here noted on the vines at Angri were due to the action of the disease known by the majority of Italian workers as Mal Nero. Prof. Cuboni did not recognize these effects as due to the action of that disease. They were not so understood at Pavia by Drs. Briosi and Cavara. They were wholly separated from Mal Nero by Profs. Cugini, Mori, and Macchiati, at Modena. At Catania, Prof. Aloi at once denied that Mal Nero, as known in that region, induced these distinctive markings of the foliage. There is reason to believe, as Prof. Comes holds the effects seen at Angri as due to Mal Nero, that such diseases as Rougeot and Folletage are confounded by him with what has been called Mal Nero. If we are to consider Mal Nero as a collective term, applied to the effect upon grape wood of various diseases, especially those of a nonparasitic nature, it is given a position of generic importance allied to the places occupied by the French terms Pourriture and Pourridié, which may not unlikely be its true position. As Prof. Comes and others have limited this term to effects quite generally conceded as arising from nonparasitic causes, and as the results produced by several causes of that nature can not be distinguished one from the other as now defined, it seems highly proper that the name should embrace all such blackening and alteration

[1] The wood affected by Mal Nero here shown me was black at the heart. Other wood shown me by Dr. Cavara was black at the surface, and in lines showing in spots in transverse sections. The presence of brown granules in the xylem is not considered by Prof. Cugini as absolutely diagnostic of Mal Nero. He said that in tuberculosis of the vine he has found similar deposits in the cells.

of the wood, especially above ground, as may arise from the following and like causes:

(1) Atmospheric and temperature conditions, embracing, as they are now understood, both Rougeot and Folletage and the effects of frost, and the subsequent effects of these within the vines. (2) Injuries of whatever nature, admitting of the oxidation and blackening of the elements of the wood, as by the entrance of water, and the resulting pathological alteration of the cell contents.

MAL NERO, ROUGEOT, AND FOLLETAGE IN SICILY.

As already stated Mal Nero first became a matter of discussion from observations made in eastern Sicily. On this account it was thought best to visit that island and study the disease where it was reported as doing most harm to the vineyards. On August 25, 1890, I went to Messina, arriving the following day. My stay lasted until October 1, and during that time the leading vine-growing regions visited were those of Messina, Milazzo, Catania, Syracuse, Noto, Palermo, Marsala, and Trapani. The greater portion of the work was done in the provinces of Catania, Messina, and Syracuse; but the eastern slope of Etna, in the vicinity of Giarre, Riposto, Milo, Annunziata, Mascali, Piedimonte, and Acireale received most time while located at Catania. Messina was my location while working in the Phylloxera-infested vineyards of Faro and the beautiful and extensive vineyards of the valley of Milazzo. Syracuse was chosen while visiting the fine vineyards of the province of that name. The valley back of Syracuse, one of the longest cultivated valleys of Sicily, is still one of the most fertile and beautiful regions of the island. The central portion of Sicily has but few vines, most of the valleys and hillsides being devoted to the raising of grain. This portion of the island was formerly as fertile as a garden, but in recent times has become greatly reduced in fertility. The coast valleys of Sicily are now its gardens, and here the vine, olive, lemon, orange, fig, peach, almond, apricot, caruba, pomegranate, and vegetables of all kinds abound.

It is on the slope of Etna, near Milo, Giarre, Mascali, and Riposto that the vines are most affected by the disease called Mal Nero by the peasants. Here the vines are grown from the sea up to the forest line. Milo is a little hamlet situated far up on the side of the mountain, and many of the vines about it are reported to have been set eighty years. Giarre and Mascali are only a short distance back from the sea, and are in the midst of the more moderately sloping and vine-covered plains at the base of the mountain. Riposto is located at the sea, directly east of the summit of Etna, and is an important wine-exporting town.

The system of vine culture generally practiced on the lower slopes of Etna is more nearly related to that of California than are the systems adopted over the most of Italy. The vines are grown low, and set in lines about as far apart each way as corn is grown in the United States. On the steeper slopes of the mountain it is impossible to cultivate vines at

the natural angle of the earth, and the entire mountain is terraced by the peasants, who use for that purpose the volcanic rocks which thickly cover the sides of the mountain. These terraces extend for miles up the mountain, one above another, and along each is growing a line of vines. The yield of these vineyards is abundant and good.

A personal examination was made of the vineyards over this entire mountain slope. After thoroughly working over this vast and beautiful vine-growing region, two vineyards near Mascali were selected for more careful study. In these many vines were found affected by what is there known as Mal Nero. The gentleman in charge indicated the vines which were diseased, but in no case did he point out vines presenting the same appearance as those affected in California.

In the majority of cases those vines shown me as affected by Mal Nero were very old, 40 years, badly blighted and decayed, some so badly decayed that they could be easily broken off just below the surface of the ground. In other cases, though not old, they were short pruned in such a manner as to injure the strength and vigor of the stock by allowing the entrance of water. In old stocks the termites had mined and done much injury. Some vines presented a short growth, but in the majority of cases no evidence of any specific disease was observed. In one place near Mascali the vines had been removed in considerable numbers, but the owner claimed it was done only because the age and general decay of the stocks had rendered them unprofitable. They were to be replaced by new and more vigorous vines, as such a thing as not being able to replace old vines was not thought of. Over the entire valley of Riposto-Giarre, and as far up as Milo, a vineyard dying as those in California die was nowhere to be seen. On the contrary, the vines from the sea to the timber line were green, thrifty, and loaded with fruit, with the exception of such as were stunted in growth on account of age or unfavorable soil conditions. Prof. Aloi, of Catania, holds that the failing of the vine stocks known there as Mal Nero is due to unfavorable conditions of subsoil. Another fact that should be taken into account is the excessive rain which suddenly falls on the slopes of Etna at the close of the dry season. These rains are much heavier and occur more frequently than in regions further from the mountain. The first rain which occurred in the fall of 1890 was very heavy, and oversaturated the soil before the fruit was gathered. This excessive moisture taken in connection with the lava soil and subsoil is undoubtedly one of the causes of Pourriture, and general debility of the plant in some sections. The evidence of a specific disease is faulty. The vineyards are mostly thrifty over the entire region where the disease is supposed to be doing its worst work. It is also said by the peasants that when a vine fails from Mal Nero it may be renewed by grafting after it is sawed off below or at the surface of the ground. In one such case a vine was producing fruit and many showed good growth. The graft usually

used is Jacques, and it is quite probable this vine forms its own roots in some cases.

The examination of the vineyards of Etna showed no such general disease there as in California, and where vines were affected by what was called Mal Nero the greater part did not show the markings of foliage as seen in California, but were mostly green and normal in color.

Coming now to another consideration in this connection it may be said that Folletage and Rougeot exist in Sicily as in Italy, France, Algeria, and elsewhere. There were several cases of Rougeot or light cases of Folletage in the Etna vineyards. On an average probably not more than two or three vines were affected in a 5-acre vineyard. In the majority of cases only a portion of the vine was killed, and in some cases only a portion was apparently affected. In other parts of Sicily there are a larger number of these diseased vines, but nowhere more than a few in a vineyard. The greatest number seen in any one vineyard was near Milazzo. Plates XVII and XVIII illustrate diseased vines here, and on Plate XIX is shown a leaf gathered from a diseased vine in an adjoining vineyard. The lower figure of the same plate is that of a leaf from a similarly diseased vine at Mascali.

In one of the vineyards on the plain of Catania was a vine affected by a partial stroke of Folletage. The ends of some of the canes were killed and the foliage highly colored, as with Rougeot. Upon being asked the name of the disease the foreman in charge answered it was "Mal Nero." The name had not been mentioned in his presence to my knowledge previous to his use of it. Here, then, was a positive case where in Sicily, Rougeot or Folletage was confounded with, or at least was identified with, Mal Nero. This is in harmony with Prof. Comes. This foreman, who appeared to be an intelligent Sicilian, affirmed that vines thus affected did not die, but that they could be saved by cutting them off and raising new shoots from the ground level, and he showed two vines which had been thus treated the previous season, and one of which was now sending up apparently healthy shoots, showing no spotted foliage. The vine first seen and not yet cut back had one long, badly diseased cane, the dying portion reaching nearly to the spur from which it arose. This cane, as was the case with many others, was evidently dying from the tip downward, and there seems no good reason why, if the disease may run through the full length of a long cane, it may not likewise be able to affect the vessels of the old wood even to the ground; and if only a single cane be affected, or a few canes on one side of an old stock, then I know not why one side of the old stock may not alone be affected, or even a small segment of one side, where are grouped the vessels functionally connected with the dying cane or canes above.[1] This would explain the death of the wood in triangular strips

[1] Prof. Viala states (Les Maladies de la Vigne) that when vines are frozen the effects are shown by the death of the tissues, which assume a brown tint. This necrosis of the tissues, if it be not checked, infects the healthy tissue as far as the root. This, he says, resembles Mal Nero.

down the side of the old vine seen in laboratory examples of Mal Nero. In more severe cases of Folletage the entire stock is killed, and this is additional evidence that the effects of the allied diseases, Rougeot and Folletage, may extend more or less throughout the old wood. This view also explains the source of progressive death and alteration of color which can not be traced to external openings or to the entrance of water. In a vineyard where a number of vines are thus affected each season it may readily appear, after the killed or badly diseased canes have been in part removed by pruning, as if the progressive alteration of the elements of the wood below where these canes were removed was something wholly new in vegetable pathology. In other words, I believe many of the dark triangular strips of wood in old vine-trunks, with their altered cell contents, are the results, perhaps progressive, of the action of Rougeot or Folletage on portions of the vine previously largely removed by pruning, or upon the part itself as found. It has been elsewhere shown that vines may blight upon sunny sides wholly independent of the action of Rougeot or Folletage. What the action of Rougeot or Folletage is upon the vine remains open for future study. That where the vine is not entirely killed the shock to it is very severe is clearly shown by the vines themselves. That the protoplasmic cell contents are affected beyond the point where actual death occurs seems to be shown by the enfeebled condition of the vine after the dead canes are removed. The practice adopted in the vineyard near Catania of cutting the vines off close to the ground, which had been injured in the green parts the preceding year, is practical evidence that the vine is affected much below the organs actually killed.

Although the cause of Folletage and Rougeot has had explanations, it has not been demonstrated. Folletage is called a "physiological accident," and it is said to cause the death of the whole or a portion of the vine through a break in the equilibrium existing between absorption and transpiration. A discussion of this view should not be attempted before a long and carefully conducted series of physiological experiments has been made. Such a work is contemplated by Prof. Foëx in the school at Montpellier, and it is to be hoped that it will be fully and carefully carried out. Prof. Cuboni, of Rome, stated that Folletage had been artificially produced in his laboratory by means of rays from a lens. The statements respecting the cause of Folletage are too conflicting and uncertain to be considered satisfactory; but the observed phenomena are capable of being defined if not explained.

The appearance of the vine affected by Folletage is largely dependent on the severity of the shock sustained. In most cases examined only a portion of the vine had been killed. From the peculiar coloring of the foliage and the bared canes the affected vines are distinguishable at a distance. Usually a portion of the canes are dead at the ends, perhaps one or more entirely dead. The appearance is somewhat like what might be produced by a ball of fire passing at one side of the vine or over

it. Some of the canes are dry and brittle and usually the ends will be found broken off. They may be shrunken slightly on one side and the bark dead and blackened. Where the shock is most severe the foliage is curled and dried, and hangs down as if burned. The death of the cane seems to progress most rapidly down the under side. Below where the leaves are dried others will be found much discolored, either with red or yellow spots or stripes. Those leaves which are suddenly killed do not become highly colored, but are brown like a sunburned leaf and much curled. On the lower parts, which have felt the shock less, the spotted leaves resemble those seen at Naples, although as the trouble is more sudden there is less regularity in the effects. The diseased state of the foliage far below the point where the cane is killed shows that the disease has weakened the entire vine. The fruit dries in a very irregular manner. Instead of all bunches on a vine suddenly drying as in California, those bunches next the affected branches are the ones to dry. On the further side of the vine both grapes and leaves may be normal.

On the place in charge of Salvatore Saporita, near Milazzo, vines are grown in a small vineyard after the Roman system, elsewhere described. In this vineyard, about half an acre in extent, were two vines affected by Folletage or a severe case of Rougeot. One of these affected vines had produced a very fine growth during the season. The cane most affected was about 10 feet long. This was mostly bare of leaves and was turning black, the blackening extending furthest down the inferior side of the cane. The spots were most developed on the old leaves still remaining close to the base of the cane. There was evidence of the very rapid death of the terminal parts. The vine appeared in other respects in perfect health and was only five years old. It is remarkable that one long cane on a vine having several such canes should be killed in a brief time, while the remainder of the vine continued to be healthy so far as external appearances were concerned. The diseased new growth could be everywhere traced by the discolored leaves.

Folletage and Rougeot seem to grade into one another in the effects which they produce on the vines, and this is done in such a manner that the two diseases are difficult to separate by definitions. Distinctions such as the complete or partial death of the vine, or the killing at once of a portion of the canes or their death by degrees after the fall of leaves are unsatisfactory. The characters of the leaf are shown on the plates of leaves from Angri, Mascali and Milazzo. The descriptions given for the leaves found at Angri will apply to the leaves affected by Rougeot.

Folletage works rapidly; Rougeot slowly. Folletage kills the wood and often while the leaves are still attached; Rougeot, if at all, after they have fallen.

Considering the diseases known as Folletage, Rougeot, and Mal Nero in connection with the California disease, what is the apparent relationship?

Mal Nero, if it exist as a specific disease, independent of such diseases as Folletage and Rougeot, certainly does not resemble the California disease either in its effects upon the vine or on the vineyard as a whole. It may then be set aside, as so characterized, so far as this investigation is concerned.

Of diseases such as Folletage and Rougeot, especially such a form as is found at Angri, Italy, it may be said that there appears to be a family resemblance to the California disease. There are many and important features of the latter, however, which distinguish it from these. The following comparisons will illustrate the differences:

The California disease.	*Folletage and Rougeot.*
(1) The vineyards are completely destroyed, every vine dying sooner or later in almost all cases and with most varieties.	(1) The vineyards are not known to ever have been completely destroyed by these diseases; vines die only in a sporadic manner and never a great number in one vineyard.
(2) Most vines die slowly, from one to five years usually being necessary to kill them. They can not be renewed by cutting back or grafting.	(2) Folletage may kill vines suddenly, or where not killed, as with Rougeot, they may be renewed by cutting back or grafting.
(3) Though sometimes showing disease unequally, the vines die as a whole.	(3) With both Folletage and Rougeot one cane may bear the heft of the stroke, being killed almost to the stock while the rest of the vine remains normal. But if we include the slow action of Rougeot, where the leaves fall before the canes die, then the stock rarely dies, or dies much less frequently than in California.
(4) The leaves almost always fall before the canes die.	(4) In Folletage death is so rapid that the directly affected leaves often remain attached to the cane. In Rougeot the fall of the leaf is much as in California.
(5) Vines have died as early and as completely on high and light gravel soil as on low heavy soil.	(5) Vines are much more commonly affected on heavy wet soils than on dry gravelly soils.
(6) The existence of this disease is recent and exceptional, and still more exceptional in its wholesale action.	(6) These diseases are not recent nor are they in any way exceptional to what has existed in the same regions in the past.
(7) The death of vineyards presents much to point toward the spread of the trouble from a center.	(7) No evidence is given by these diseases that they spread from a center.

Besides presenting the above facts I will say that I have the evidence of several leading scientists that the California affection is not Folletage. Dr. Foëx, of Montpellier, states that Folletage is always sporadic and that in his opinion our California disease is wholly distinct from that disease. He also says that Folletage is not the same as the trouble in Algeria produced under the influence of the sirocco. In the latter case it is nothing more or less than a burning up of the foliage of all plants, and these plants will produce new growth as is usual in case of most

burned plants, when not killed. Dr. Foëx further says that vines affected by Folletage in southern France will sometimes survive by being cut back, and this agrees perfectly with my own observations. Folletage, he stated, never extends over a continuous surface, and this was also the statement of his assistant, M. Rabot. The experience of these gentlemen is very valuable, as the region best suited for a study of Folletage, I am informed, is southern France.

Prof. Gayon, of Bordeaux, said that Folletage never killed vines over a continuous surface; that it was sporadic, as proven by my own observations. Prof. Cuboni, of Rome, also said respecting the action of Folletage, that it is sporadic and never known to be general in a vineyard. Rougeot, it is generally conceded, does not kill the entire vine.

The preceding facts are sufficient to show that the California disease, although in some respects allied to Folletage and Rougeot, and especially to the latter, still has unexplained elements which have yet to be harmonized with observed facts respecting those diseases; or else these diseases must be wholly excluded from the list of possible causes. Their exact action also remains to be more thoroughly demonstrated.[1]

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[1] The following is a partial list of the literature referred to, either directly or indirectly, in the work on Mal Nero:

Fiorini, Paolo Cali. Atti della Società di Acclimazione e di Agricoltura in Sicilia. Tomo III, 1863.

Sommer. Eine neue Krankheit des Weinstocks. 1869.

Luxardo and Gregori. Rivista di Viticoltura ed Enologia. Vol. I, 1877.

Grassi-Patané. Giornale d'Agricoltura, Ind. e Comm. del Regno d'Italia. 1877.

Garovaglio and Cattaneo. Studii sulle dominanti malattie dei vitigni. Arch. del Labor. crittogam. di Pavia. Vols. II and III, 1878.

Rotondi and Galimberti. Rivista di Viticoltura ed Enologia. Anno II, 1878.

Ravizza and Galimberti. Sull' anthracnosi della vite. 1879.

Targioni-Tozzetti. Annali di Agricoltura, Florence. 1879–1888.

Trevisan. Il Mal Nero e la Fillossera. Rendiconti del R. Istituto Lombardo. Series II, Vol. XIII, 1880.

Cugini. Ricerche sul Mal Nero della vite. Bologna. 1881.

Garovaglio, S. La vite ed i suoi nemici nel, 1881. Milan.

Comes. Sul preteso tannino solido scoperto nelle viti affette dal Mal Nero. 1882.

Comes. Primi risultati degli esperimenti fatti per la cura della Gommosi o Mal Nero della vite. L' Agricoltura Merid. Anno V. Portici, 1882.

Cugini, G. Nuove indagini sul Mal Nero della vite. Giornale d' Agricoltura, Industria e Commercio del Regno d'Italia. 1882, Nos. 10, 11, 12.

Pirotta. Primi studii sul Mal Nero o mal dello spacco nelle viti. From Le viti americane, la fillossera, etc. Ann. I. Alba, 1882.

Cugini. Il Mal Nero della vite. Extract from the Giornale L' Agricoltura Italiana Anno VIII, fascicoli XCVII–XCVIII–XCVIX. Florence, 1883.

Comes. Sulla Rhizomorpha necatrix, Hartig, e sulla dominante malattia degli alberi 1883.

Coppola. Sul Mal Nero della vite. Cagliari, 1883.

Comes. Sul marcinme delle radici e sulla gommosi della vite nella provincia di Napoli. L' Agricol. Merid. Anno. VII, No. 11. Napoli, 1884.

Turrisi-Scamacca. Relazione intorno ai lavori della R. Staz. Ent. di Firenze, 1884.

Aloi, A. Una rivendicazione di priorità sulla origine del Mal Nero della vite. Catania, 1884. L' Agricoltore Calabro Siculo, Anno IX, N. 12.

De Gregori. Ann. della R. Scuola sup. di Agricoltura in Portici, 1885.

Comes. Come Provverdere al marciume delle radici nelle piante fruttifere e specialmente nella vite. Milan, 1885. Extracted from L' Italia Agricola.

Cugini. Intorno ad una malattia delle viti detta Mal Nero. Sviluppataosi in Toscana. Florence, 1886.

Viala, P. Les maladies de la vigne. Montpellier, 1887.

Comes. Il Mal Nero o la Gommosi nella vite ed in qualsiasi altra pianta legnosa e gli eccessivi sbalzi di temperatura. Naples, December 1, 1887. Extracted from the Annuario della R. Scuola Superiore d' Agricoltura in Portici, vol. V, fasc. iii.

Mori, A. Sopra una malattia delle viti. L' Agricoltura Italiana. Vol. III, p. 455, tab. iv.

Cuboni, G. Mal Nero della vite. Nota dei casi di malattie dei vegetali presentati alla R. Stazione di Patologia Vegetale di Roma dal 1° dicembre 1888 al 30 aprile 1889. Rome, 1889.

Macchiati, L. Bollettino della R. Stazione Agraria di Modena. Modena, 1890, pp. 76–82.

Casoria and Savastano. Il Mal Nero e la tannificazione della querce. Studio dei dottori E. Casoria e L. Savastano, presentato dal Socio Tommasi-Crudeli. Roma, 1889.

Comes. Malattie della vite nella provincia di Salerno.

CHAPTER X.

REMEDIES AND SUGGESTIONS FOR TREATMENT.

Under the head of remedies will be presented notes taken in the field respecting the labors of vine-growers to save their vines and such facts of observation and experiment as a brief time in California has enabled me to gather. It has not been possible within a single season to do much more than to study the nature of the disease, and only those who have had the advantage of occupying the field from the very inception of the disease will be able to recognize the extent of the labor required in this investigation, independent of extensive field experiments with preventives.

The salts of copper, so effectively used in various forms for destroying *Peronospora viticola* in France and elsewhere, have become a staple remedy for several fungous diseases of plants. On this account, although the nature of the disease in California is undetermined, many experiments with this fungicide have been conducted by the vine-growers.

As many of the vineyards were treated with two or more substances, it seems best to give the vineyard records as a whole rather than to consider the substances applied separately. In the preparation of Bordeaux mixture different proportions of the ingredients have been used.[1]

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[1] At present the proportions recommended for use by the Department of Agriculture for the treatment of most plant diseases are as follows: *Bordeaux mixture.* Dissolve 6 pounds of sulphate of copper in 40 gallons of water; 4 pounds of fresh lime slaked in 6 gallons of water. When cool, mix the two by pouring the lime solution slowly into the solution of copper, combining them thoroughly by constant stirring. Air-slaked lime should never be used, nor should the putty of lime which is made by plasterers.

A stronger mixture which is not intended for the foliage, but to be used for black rot or other diseases where it is desirable to treat the body of the plant before vegetation starts in the spring, may be made as follows:

Dissolve 16 pounds of sulphate of copper in 22 gallons of water; in another vessel containing 6 gallons of water, slake 30 pounds of lime. Mix these solutions as in the first formula.

Another mixture, called *eau celeste*, is made as follows, without the use of lime:

Dissolve 1 pound of sulphate of copper in 2 gallons of hot water; when completely dissolved and the water has cooled add 1½ pints of commercial ammonia (strength 22° Baumé); when ready for use dilute to 22 gallons.

The second solution is made by dissolving 2 pounds of sulphate of copper in 2 gallons of hot water; in another vessel dissolve 2½ pounds of carbonate of soda; mix the two solutions, and when all chemical reaction has ceased add 1½ pints of ammonia, then dilute to 22 gallons. A good spraying pump should be used in making the applications.

REMEDIES APPLIED TO VINEYARDS.

Vineyard 1.—Close to the city of Los Angeles was a vineyard of some 240 acres, largely of the Mission variety, in charge of Mr. F. Roueau. They showed distinct signs of disease in 1888 and were treated with the Bordeaux mixture in 1889 with the hope of saving them. Four applications were made both before and after the leafing of the vine; one to the body of the vines after pruning and three after the season of growth began. These four applications cost $3,000, but no vines have been preserved. Most of them, especially those of the Mission variety, were nearly dead at the close of the summer of 1889.

Vineyard 2.—The George Nadeau vineyard, near Florence, was treated with Bordeaux mixture in 1889, but when examined near the middle of the summer the vines were badly diseased and rapidly dying. When treated they looked well. These vines were mostly of the Mission variety, were young, and on good soil. A portion of the vineyard had been treated with sewer water from Los Angeles.

Vineyard 3.—The Nisson vineyard, near Santa Ana, was composed of 16 acres of vines; 8 acres of Muscats, 5 of Black Malvoisie, and 3 of Bergers. Disease was first noticed in 1886; in 1887 it became more distinct, though the vineyard was treated three times that season with the Bordeaux mixture. The vines seemed to be somewhat stimulated by the mixture, but none were saved. The vines were on good soil and well cared for, and were mostly removed in the winter of 1889–'90.

Vineyard 4.—At San Fernando Mr. C. R. Rinaldi had several small Mission vineyards on good rich soil. A portion of them were treated five times with the Bordeaux mixture and others seven times. None of the vines were saved. The disease has not yet made as thorough a sweep of the vines in the San Fernando Valley as near Anaheim, but from the gradual death of vines it is evident the entire vineyard area there will soon be worthless.

Vineyard 5.—Mr. W. D. Whelan, near Florence, treated his vines with the following mixture: 8 pounds of copper sulphate, 8 pounds iron sulphate, 25 pounds of lime, and 60 gallons of water. His vineyard was of the Muscat variety and had been fertilized with sewer water from Los Angeles. The vines, although showing disease, were comparatively healthy on August 29, 1889, but the entire vineyard has since been removed.

Vineyard 6.—Mr. G. Mirande, of Pomona, was the first man, so far as I have been able to learn, who made use of the Bordeaux mixture on the diseased vines in southern California. According to the Pomona Progress Mr. Mirande's first preparations for spraying were composed of 2 pounds of copper sulphate dissolved in a pail of hot water, 3 pounds of slaked quicklime, the whole well stirred in 50 gallons of water. This preparation was used on dormant vines. After the leaves had started they were again sprayed, and it is said they responded to this treat-

ment by a new growth. A third treatment was made before fall and with like results. The treatment was continued for more than one year. On September 24, 1889, I found many of the vines had already died, and much of the vineyard was badly diseased. It was apparently only a matter of time until all the vines would be destroyed. Beyond the immediate effect of the applications there was evidently no great good derived from the treatment. The nature of the soil and distance from the central point of the diseased districts was evidently saving all the vineyards about Pomona for a time.

Vineyard 7.—Mr. Brigham, of Florence, treated his Mission vines with the Bordeaux mixture three times during one season. The first application was made before growth started, and the second and third after the foliage had formed. None of these vines were saved, and although they are all dead, Mr. Brigham thinks he has aided his Muscat vineyard by the same treatment, and he proposes to continue it in 1891. The vines responded to treatment by a new growth. The Muscat vineyard has since become worthless.

Vineyard 8.—Albert Kruth, of Orange, had 12 acres of Muscat vines which he treated with the Bordeaux mixture the first year he noticed the disease. His treatment proved ineffectual, for the vines all died. He thinks no beneficial effects were felt by the vines from the use of the mixture.

Vineyard 9.—Mr. A. W. Thaxter, of Florence, sprayed his vines with the Bordeaux mixture in 1889. On July 10 I noticed they had produced a second growth. It is probable that the new growth was the result of the treatment, though at the time I held the opposite view, but the treatment did not save the vines.

Vineyard 10.—A vineyard in charge of Mr. Hager, northwest of Orange, comprised 300 acres, mostly of Muscat vines. It was treated with the Bordeaux mixture. The vines lingered much longer than those nearer Orange. Mr. Hager is confident a new growth can be at once induced in vines after treatment with the Bordeaux mixture. The true reason for the long life of the "Hager vineyard," however, was the youth of the vines and the sandy nature of the soil rather than the treatment it received.

Vineyard 11.—Mr. S. G. Baker, Norwalk, used the lime and bluestone wash and sometimes copperas combined on nearly all his vines during 1889. He says the treatment "does not fill the bill" though the vines lived longer than others untreated. The preparations were of all strengths, and the vines were "washed" from one to six times. The old vineyards of Norwalk are now almost entirely dead. The 30-acre vineyard of John S. Baker is three-fourths of a mile southeast of Fulton Wells, and contains numerous varieties. The Bordeaux mixture was here freely used, but was applied to the canes, spurs, and body of the vines rather than to the foliage. The vines were washed for the first time before they leafed out in the spring. The second application

was made shortly after the leaves came out. A few vines were treated for a third time some three or four weeks later. Those having the third treatment, being the most affected, were again treated twice or three times after intervals of two weeks. The mixture applied was of extra strength and was applied with a brush to the old wood of the vine till the bark was thoroughly saturated. The later applications were not as strong as the earlier ones, as the leaves were at first injured. The first and second applications were made with the following mixtures:

No. 1: 10 pounds of lime, 10 pounds of sulphate of copper, 5 pounds of sulphate of iron, 30 gallons of water.

No. 2: 20 pounds of lime, 5 pounds of the sulphate of copper, 5 pounds of the sulphate of iron, 50 gallons of water.

After the vineyard had been treated with each of the above mixtures it was treated with the "Ongerth powder."[1] This powder was applied to the body, canes, and foliage of the vines by means of bellows. A portion of the vines received three applications and the remainder one. On August 26, 1889, the vines that had been powdered three times were in no better condition than the others. The first application was made about three weeks after the last treatment with the Bordeaux mixture, the second some four weeks after the first, and the third six weeks after the second. The third treatment was made the last of July. The entire vineyard was also sulphured for *Uncinula*. The vineyard was quite generally diseased, and Mr. Baker believes the vines can not be saved with either the Bordeaux mixture or the Ongerth powder; but badly diseased vines are stimulated or aided to new growth after an application of the Bordeaux mixture. [This vineyard still lives.—May, 1892.]

Vineyard 12.—Under the head of "growth of healthy cuttings" are given the records of a vineyard near Orange, in charge of Mr. O. Handy, and known as the "Handy vineyard of Riverside cuttings." Of all the vineyards noticed this one received the most thorough treatment, and the most persistent efforts were made to save it. It was a test of the value of Bordeaux mixture in saving vines in this region from the California disease. The vines were set in the spring of 1888. Early in the spring of 1889, when the vineyard had made a good growth during the preceding season, Mr. Handy had the vines thoroughly sprayed with the Bordeaux mixture. On May 28 he went over them again and gave a thorough treatment with the Ongerth powder. On July 12, 1889, they were treated again with the Bordeaux mixture, and the vines grew from 7 to 16 inches in the next twelve days. This was, however, all the marked effect produced. The vines went back toward the last of

[1] What is now known in southern California as the "Ongerth powder," or by some as the "Shorb powder," is a compound manufactured by a San Francisco house. It came before the public as a remedy for the vine disease through the published notices of the work of Mr. Dowlen and Mr. Shorb. Large quantities of it were used in all parts of the affected district, and reference to experiments made by vine-growers with this powder will show the results of its use in various places. These records could have been multiplied largely had it seemed necessary and had time permitted.

the season. They were again treated after pruning in the winter of 1889 and 1890. The mixture was as follows: Twenty pounds of lime, 8 pounds of sulphate of copper, to 50 gallons of water.

The bodies of the vines were thoroughly saturated about January 25. The treatment followed during the summer of 1890 was not ascertained, but the death of a large percentage of the tops in the fall of 1889 clearly demonstrated that any ordinary treatment with the Bordeaux mixture would not save the vines from this disease.

Vineyard 13.—Mr. M. Mendelson, of Capistrano, used the Ongerth powder, applying it thoroughly with bellows. There was no effect produced on the disease by this treatment. His vines are now all dead.

Vineyard 14.—Mr. A. M. Aldrich, of Riverside, applied the Ongerth powder to his vineyard of Muscat vines. The vines were young, having been set in April, 1884. The first application was made June 1 with a sack, and the second July 15, 1889, with bellows. Sulphur was mixed with the last application. The vines were irrigated about June 15 and July 25. The disease was still spreading.

Vineyard 15.—This vineyard of 15 acres belonged to Mr. Edwin Hart, of Riverside, and was of Muscat vines. Certain badly diseased vines were treated with the Ongerth powder about June 1, June 30, and August 15, 1889. The powder was blown with bellows into the bark of the body of the vine. The foreman's opinion was that the vines were not in the least benefited. They were irrigated about May 5, June 17, July 10, and August 4, the water running forty-eight hours.

Vineyard 16.—Mrs. L. C. Chamblin's vines at Riverside were treated on June 10, 1889, with the Ongerth powder. The application was made with bellows, and the effort was made to put the powder on the under surface of the leaves, except in badly diseased vines, which were powdered throughout. No effects were observed due to the action of the powder.

Vineyard 17.—Mr. A. P. Johnson's vineyard of Muscat vines is about 2½ miles south of Riverside. In the season of 1889 it was treated with the Ongerth powder in a most thorough manner. The vines were powdered four times, the applications being made with bellows to the body of the vines. The results were not beneficial so far as the observations of the foreman extended. He says he "might just as well have powdered them with dust."

Vineyard 18.—The vineyard of the B. D. Wilson estate at San Gabriel was treated twice with the Ongerth powder in the season of 1889. The vines, however, have all died of the disease. Mr. Fargoe's vines of the same place were also powdered, and were dying in 1889.

Vineyard 19.—The D. H. Burnham Muscat vineyard at Riverside was treated with Ongerth powder in 1889. The treated vines were not in any better condition than untreated ones.

Vineyard 20.—Mr. J. G. White, foreman of the large Nadeau vineyard, near Florence, made a thorough test of the Ongerth powder.

Three applications were made to the vines and no good results were observed. The sulphur in the compound did not prevent *Uncinula*, so he afterward sulphured them. [This vineyard is now removed.—May, 1892.]

Sulphuring the vineyards was the common practice in southern California for a considerable number of years prior to the appearance of the disease. This practice was kept up after the vineyards began to die. Nearly all the dead vineyards have been sulphured. The vineyard of Mr. Carroll, at Anaheim, the first to be removed on account of the disease, had been sulphured three times during the season; once about the time it leafed out and twice later.

SPECIAL TREATMENTS.

A considerable number of special treatments of diseased vines have been made. It must be understood that, owing to the nature of the disease not being known, many of these tests have been made blindly. Such experiments need not be detailed here.

Several special treatments of a few vines have been made with the Bordeaux mixture, six or seven applications being made to some vines in one season. A number of tests have been made with carbolic acid of various strengths applied in different ways. Sulphur has been used in special tests. It has been applied to the foliage, the body, and the roots of the vine, both alone and in compounds. Coal oil, turpentine, and benzine have all been applied in different ways. Burning the top of the vine and cutting back vines have been tried. The results of the latter experiments are considered in a previous chapter.

A series of experiments with bichloride of mercury (corrosive sublimate) were conducted by the author on vines which had been cut back. Various strengths were used. Some were treated upon the spurs and body, others by boring, and another series had the roots treated. The treated foliage was burned in most cases. Those vines which had had the bark saturated seemed at first to produce a new growth more healthy than those treated at the roots or elsewhere, but in a short time this growth became badly diseased and the vines virtually died. Some have tried lime about the vines with little if any effect.

What are we to conclude respecting the efforts thus far made with preventive or curative preparations, and what general recommendations seem to present themselves? It may be safely stated that at present no remedy is known which will save vines after they have become badly diseased. The consensus of opinion respecting the action of the Bordeaux mixture is that it acts much as would a stimulant. How this effect is produced is as yet uncertain. I here refer to the application to the foliage and canes as they are treated for *Peronospora*, and have been treated in California. From many sources the statement is that a new growth may be quite surely induced by means of this treatment. There is little doubt of this. If it be a true stimulant, or if it acts

directly on the cause of the disease, it is of importance, and I should recommend the treatment of newly set vineyards with this preparation, or with *eau celeste*, as an aid to the vine although it may ultimately die. For the old and badly diseased vines nothing but removal can now be recommended. All treatment should begin early in the season, and three or four applications should be made. The spraying pump had better be used in all cases, as this enables much of the under surface of the leaves to be reached, and mixtures are more evenly distributed than by the methods commonly used in southern California.

The vine-grower should not lose sight of the sulphur treatment simply because he applies the Bordeaux mixture. It can not be too strongly fixed in the mind that *Uncinula* (*Oidium*) is capable of doing much to weaken the vine, and that the treatment which keeps the fruit free from this fungus is wholly insufficient to free the entire vine. The sulphur bellows should be used, and the sulphur should be blown over all the leaves on the under surface. The new foliage and canes should be kept as free from *Uncinula* as any other portion of the vine. Treatment is required early, and it should be repeated often, so that there is no opportunity afforded of weakening the vine. If possible subirrigate, or irrigate slowly and not overabundantly in the dry season, where irrigation is required.

These few recommendations, coupled with a start from perfectly healthy cuttings, are about all that can be safely made now. Many vineyards have died under similar treatment, but the appearances are that the day will come when vineyards thus cared for will become profitable investments. Experiments will be continued and extended, and when methods are learned whereby vines can be saved the first opportunity will be taken to lay such observations before the vine-growers; until then let no pains be spared to keep the vines free from *Uncinula*.

CHAPTER XI.

GENERAL REVIEW AND CONCLUSIONS.

The review of viticulture in Mexico and the peninsula of Lower California, combined with that of about one hundred and ten years of vine-growing in southern California, has clearly shown that no widespread death of vines similar to that occurring since 1884 has ever before been known in North America, although the vine now most susceptible to the disease has been grown on the continent for more than three hundred and fifty years. The exceptional nature of the malady is thus established. It has also been shown that if climatic conditions have any causal relations to the death of the vines, these conditions are both recent and exceptional. Hence, the examination narrows the matter and period to be investigated down to the exceptional phenomena of a single decade.

The history of the first appearance and spread or later development of the disease is of great importance in exhibiting the workings of the malady. They become of diagnostic value and are matters of necessity and of great importance; and although more time might have made this portion of the report more complete, the facts given outline fairly well the development of the disease and the characters of the dying vineyards. The facts point to the present existence of the inciting cause of the disease as either an external parasite or as internal and cumulative.

The special characters of the disease have been given with care, and I think are in harmony with the observations of a majority of the vine-growers. The records give many valuable facts as to the effects of the disease on the vine. To understand the value of these records we have only to note how large a percentage of human diseases are alone diagnosed by an examination of the state of the patient. I think that the action of the present disease on the vine is outlined sufficiently, with the exception of those characters which must be added from a thorough comparative histological and physiological study of both diseased and healthy plants. This work has been already begun, but it is not sufficiently mature to justify reporting upon. This is very important, as it will doubtless throw new light upon the disease, and will supply a much-needed standard of comparison for future work with other vine diseases.

The various conditions in California bearing on this disease have been

thoroughly canvassed. Vineyard records have been given of eighteen vineyards, and these have been convenient to refer to throughout the report, as well as supplying an actual record of facts for comparing the various influencing conditions, such as soil, etc. Drainage in its various phases is shown to have no important relation to the disease, and may be considered as a closed line of investigation. Irrigation is also sufficiently treated, and evidently has no direct and doubtfully any important indirect relation.

The rainfall conditions are among the more important ones reviewed, for exceptional rainfall certainly occurred in the season of 1883–'84. But the effects of this rainfall are largely excluded as a direct cause of disease, and appear to satisfy only the requirements of the other observed phenomena when considered as having an indirect bearing.

The question of soil poverty as a cause of disease seems to require no further study, and it is practically closed. Fertilizers as aiding in tiding over slight effects of the disease may perhaps be considered further. The physical features and nature of the soil are shown to have only a secondary bearing. Vines die on all soils, though rich sandy soil preserves them longest. The analysis of soils has not been considered at any great length, but it is believed sufficiently so to indicate that it is questionable whether further investigations of the kind need be undertaken. The investigations into the effects of shade seem to be of prime importance; and although the effects are carefully noted and reliable, the nature of the influence must still continue to be studied. It remains to be seen whether the results arise from the influence of reduced light or temperature on the physiological activities and needs of the vine itself, or whether they arise from the action of lowered temperature on parasites. One of the most obscure and in some respects most unsatisfactory lines of investigation has been the effect of variations of temperature.

No great variations of temperature have been found which it seems possible could have alone produced the widespread havoc among the vines which has occurred since 1884. The effects of heat are evident; but why a not excessive heat in 1884 should kill, or induce a disease which should kill thousands of acres of vines, while heat in any year for three hundred and fifty years prior to this date had failed to produce such results, is certainly not evident at present; and, although the effects of temperature can not well be denied, the investigation has gone far enough to throw grave doubt upon it as the cause of the death of the vines. Any radical change of climate is disproven, but the indirect bearing of heat is important and worthy of further consideration. There is no evidence that fogs or winds have caused the disease, and it is equally plain that methods of cultivation and pruning are not the cause of it. Cutting back vines or cutting back and grafting are shown to have failed to save diseased vines. The subject of resistant stock is not wholly closed, but there is strong

evidence that resistant or hardy native stocks will not save *V. vinifera* tops. Study of the hardiness of varieties has shown that the power in some is greater than in others to resist the disease. But no variety can positively be said at this time to be free from disease, while all *V. vinifera* varieties in the region have died.

Under the head of growth of diseased and healthy cuttings it has been shown, with very little doubt, that the disease persists in southern California and that it has infected and killed many vines since the death of the first vineyards. This is a fact of the utmost importance and throws the gravest doubt on the direct bearing of climate. Hence it is one of the lines of inquiry demanding further investigation. In considering the relationship of the disease, most of the parasites known to injure vines have been excluded from any connection with the California malady. The bearing of *Uncinula spiralis* should have a liberal share of future attention. This line of inquiry is not closed. So far as external characters are concerned, the affinities of our disease are seemingly with Rougeot and Folletage, while its effects in the vineyards as a whole are entirely distinct from those of either of these diseases as known elsewhere. The true nature of Rougeot and Folletage is important and should be thoroughly investigated. In respect to Mal Nero the state of the vineyards where this disease exists is wholly against the view that the California disease is the same as Mal Nero in Sicily, whether it has any relation to the vine disease at Angri or not.

The bacteriological side of the investigation has thus far given only negative results, and until time permits the experiments already instituted to be completed this phase of the investigation need not be reported. That bacteria are present in the diseased vines is quite clearly established. They have been isolated and cultivated in various media. Several series of inoculation experiments with healthy vines have been conducted in California, besides others by Mr. B. T. Galloway, at Washington. The vines for the California experiments were procured from Missouri and from the northern portion of California. That the bacteria, isolated from the inner tissues of the vine, bear any causal relation to the disease is not, however, established and may be very justly questioned.

The following may be said in relation to the observed phenomena of the disease and their reference to some disease-inciting agency:

(1) The observed phenomena would be mostly explained if we consider the disease to be due to an epidemic caused by an external parasite arising after the wet season of 1883–'84, and spreading with greatest virulence from the vicinity of Anaheim. This parasite must be capable of working during the most heated portions of the year, and must exist at the present time, although working with less intensity than at first. *Uncinula spiralis* is the only parasite yet known in the region which even approximately satisfies these conditions, but more than

normal virulence would have to be assigned this fungus to explain the observed results.

(2) The observed phenomena would be in the main explained if there were a form of micro-organism within the vine capable of altering the normal physiological relations of the plant at the heat of the season, and which organism began to spread in the Santa Ana Valley about the year 1884.

(3) A weakened condition of the cell contents, acquired under exceptional local conditions at some single period in the past, and which is persistent and cumulative from one hot season to another, would in part explain the observed phenomena. The objections to this explanation are: (*a*) The cause and nature of such a weakness are not fully apparent; (*b*) it does not account for the death of vines grown from unaffected cuttings since the disease appeared; (*c*) it poorly harmonizes with the health and normal productiveness of old vines for several years subsequent to the death of the first vineyards.

EXPLANATION OF PLATES AND CHARTS.

PLATES.

PLATE I:

Muscat of Alexandria vineyards in the Upper Sweetwater Valley, east of San Diego, showing the general system of planting and cultivation in southern California. They fairly represent the appearance of the vineyards in the Santa Ana Valley prior to the appearance of the disease. The stand usually obtained from cuttings in Orange and Los Angeles counties prior to the advent of disease was equal to that shown in these vineyards, or even better. These vines are grown without irrigation, in a region having less annual rainfall than the Santa Ana Valley. Compare with Plate II. From photograph.

PLATE II:

Mission vineyard near Los Angeles, which has been killed by the disease. The vines were very old, and the completeness of the death of the vines is well illustrated, only about a dozen vines still living in the spring of 1890, when the photograph was taken. The size of the stocks indicates their thrifty and uniformly healthy growth for more than a quarter of a century on this same soil. This vineyard is on nonirrigated ground. It is a type of the vineyards, both old and young, in the later stages of the disease. From photograph.

PLATE III:

A Berger vine from the vineyard of F. Gerken, northwest of Orange, September 19, 1889, showing the sudden action of the disease. This vine was a type of the majority of the vines and may be known as the first stage of the disease. Some twenty-five large bunches of grapes were carried by this vine until full grown. Within two or three weeks the leaves fell and the fruit dried. The unripe condition of the bared canes is typical of the disease. The sound condition of the roots near the stock at this stage, except where they were broken in removing the vine from the ground, is shown. Later they become rotted as shown in Plates IV and V. This vine was in apparent good health through the greater part of the season of 1889. The fruit normally clings to the vine, especially in this variety, when affected by the disease. Comparing this vine with those in later stages of disease, presented on Plates IV and V, it is seen that the production of secondary roots is subsequent to the first obvious appearance of disease. It should also be noted that all bunches of fruit are alike affected, showing the action of disease to be general. From photograph.

PLATE IV:

Muscat vine as it appears in the second and third years of visible disease. The growth is stunted and the leaves have fallen first from the basal parts of the cane, as in the first year of the disease. This vine was in its prime, and presented a perfect stock with the exception of the effects of the disease. The portion of the stock last to lose its vitality is shown by the production of secondary roots. The loss of the bark from badly decayed roots is shown in this figure. The system of pruning commonly followed in southern California is here seen. From photograph.

PLATE V:

Vine in the last stages of disease, from vineyard of M. Nisson, Santa Ana. The top is dead and all the old roots have decayed. The secondary roots appear as with the vine shown in Plate IV. The ground shoot is shown, and its healthful appearance when the main stock is nearly dead is characteristic of the disease. The ground line shows the proportion of the vine above and below the surface of the earth as the vines are set in most vineyards in California. Compare with Plates III and IV. From photograph.

PLATE VI:

Healthy and diseased Berger grapes, from vineyard of F. Gerken, Orange. The bunch on the right was in nearly the condition of that at the left prior to the sudden appearance of the disease in September, 1889. See Plate III. The berries are not burst open as when directly affected by *Uncinula*. From photograph.

PLATE VII:

"Golden Chasselas" grapes; healthy and diseased, from Gerken vines, Orange. These were gathered at the same time as those on Plate VI. Their appearance is in part due to the action of *Uncinula*, and is the unusual effect of the California disease, as the grapes commonly attain a greater size before shrinkage takes place. From photograph.

PLATE VIII:

Effect of the disease on the Lenoir grape from Anaheim and on a bunch of "*Vitis Girdiana*" grapes from a cañon about 2 miles northwest of San Gabriel. Gathered in season of 1889. From photograph.

PLATE IX:

A young Muscat vineyard in a late stage of disease, on the ranch of D. Hewes, near McPherson. The variation in hardiness of individual vines is shown in the background. That portion of the plate shows here and there a vine with a fair sized top, while most of the vines are dead. In the foreground is a group of vines preserved for several months by the land being somewhat lower and more moist and the bodies of the vines covered with earth, mostly sand. The vineyard is largely on heavy adobe soil and under the Orange irrigating system. From photograph.

PLATES X AND XI:

These plates should be considered together. They illustrate the effect of shade in retarding the work of the disease. Plate X shows vineyard of Dr. S. S. Wood, McPherson, of the Muscat variety, and of young vines. They are seen to be almost entirely dead with the exception of a few rows near the shade shown at the right of the plate. This shade is given by a heavy hedge of pepper trees extending along the south line of the vineyard and shown in Plate XI. It extends much further into the field during the middle of the day than is here shown, covering the nearer rows of the vines through the more heated hours. Plate XI gives a view of the trees along the south side of the vineyard and a portion of the vines preserved through the action of the shade. Compare with Chart I, showing shade effects in another vineyard. From photograph.

PLATE XII:

Cane from a diseased Muscat vine from Orange. Showing the stunted growth in late stages of disease with leaves of normal size and correct proportions. It also exhibits the characteristic markings of the leaf due to the disease, and the order in which they occur. The terminal leaves are normal, followed by those with spots, below which they are striped, while at the base the tissue is dead and broken. Compare with Plates III and IV for order of leaf fall. From photograph.

PLATE XIII.

First stages of a disease at Angri, Italy, which resembles Rougeot, but which Dr. Comes identifies as "Mal Nero." The light lines running about the main venation of the leaves in the plate represent the red or yellow lines of the leaf, lying between the green or normal tissue, next the veins, and the dead tissue further from the main veins and at the margin of the leaves. Compare with Plate XIV and with Plate XX, showing the colors of the diseased leaves. Redrawn from photograph.

PLATE XIV:

Second stage of same disease, showing the green canes left bare by the premature fall of the leaves. The leaves were spotted as in California, and as shown in Plates XIII and XX. Redrawn from photograph.

PLATE XV:

Foliage of a single diseased cane. The figure shows the progressive stages of the foliage markings at Angri, Italy. The characters agree with those observed in California and shown on Plate XII. The cane came from a large and thrifty vine, but one which was badly affected by this disease and had a considerable number of spotted leaves. Redrawn from photograph.

PLATE XVI:

A vine from Duvivier, Algeria, showing strongly spotted foliage, similar to that seen in California. The vine illustrated was the only one in the vineyard affected in this way. The trouble seems to be a form of Rougeot. The vine produced white grapes, hence the spots of the leaves were bright yellow instead of red, as in dark varieties. It much resembled vines affected in California. Redrawn from photograph.

PLATE XVII:

A typical case of Folletage of an affected vine at Milazzo, Sicily. The dried leaves, the bare canes, and the spots on the remaining leaves are characteristic of this disease. This is a case where only a portion of the vine was at first killed, this being more common than where the entire vine is suddenly destroyed. The vine was grown after the French system generally adopted in California. See Plate XVIII. Redrawn from photograph.

PLATE XVIII:

A typical case of Folletage which involved only a portion of an affected vine at Milazzo, Sicily. The dry leaves show where the shock was most severe. The canes were dry and dead and the ends had been broken from several. Many of the leaves had fallen; others, toward the base of the cane, where they still remained attached, were spotted in some cases as when affected by Rougeot. The worst attack was in this instance almost in a circle at the top of the vine. In other cases it involved the entire vine or only one cane or one side. This vine was grown after the French system commonly seen in California. See also Plates XVII and XIX. Redrawn from photograph.

PLATE XIX:

Folletage as it affects the leaves of a vine not at once killed. Figure 1, leaf from a diseased vine at Milazzo, Sicily; Figure 2, from a similarly affected vine at Mascali, Sicily. Both vines were grown after the system practiced in California. The vine at Milazzo was 5 years old and had one new cane 12 to 15 feet in length, which was suddenly killed at the end, and the colored leaves were near its base. The remaining parts of this vine were apparently in perfect health. The growth of the entire vineyard was luxuriant, the soil being rich and fertile. The vine at Mascali, from which leaf No. 2 was gathered, was in fertile ground, and was the only one seen there which showed this disease. In both cases the vineyards were loaded with fruit. From dried material. Compare Plates XX–XXIV.

PLATE XX:

Vine disease at Angri, Italy, resembling Rougeot, but identified by Dr. Comes as "Mal Nero." Figure 1, leaf of a vine producing light fruit; Figure 2, the leaf of a dark variety. Both show a well-advanced stage of the disease. The spot stage preceding the stripes is at the left of Figure 1. Not over-colored and typical of the disease. M. F. Bradshaw, from pressed material. Compare Plates XIX, XXI–XXIV.

PLATE XXI:

California disease. Leaves from Jacques vines, vineyard of A. Langenberger, Anaheim. Two stages of the disease shown. Figure 1 is the earlier stage. The leaves are typical of one of two classes of dark grapes. The other class is represented on Plate IV, and in this the tissues turn red instead of yellow. The gum spots often observed in this malady are very distinct on the upper leaf. From fresh material, M. F. Bradshaw. Compare Plates XIX, XX, XXII-XXIV.

PLATE XXII:

California disease. Leaves from Flaming Tokay vines, vineyard of George W. Minter, Santa Ana, showing two stages of the disease. The colors are not overdrawn; the leaf being often as highly colored as any autumn leaf. On badly diseased vines the first growth of spring will have the colors as represented. Figure 1 is an early and Figure 2 a later stage of disease. This plate illustrates the appearance of the leaves in the second division of the dark varieties. From fresh material, M. F. Bradshaw. Compare Plates XIX–XXI, XXIII, and XXIV.

PLATE XXIII:

California disease. Leaves from Muscat of Alexandria vines, grown at Orange, showing the spot and "fern" or "skeleton geranium" stages of the disease. The appearance represented in Figure 1 occurs earlier than that of Figure 2, and is more common, as the leaves often fall before assuming the latter appearance. The appearance seen in Figure 2 often occurs at the base of canes bearing leaves like Figure 1 nearer the end. The plate, as a whole, gives the typical effects of the California disease on leaves of most varieties producing white grapes, *i. e.* of *Vitis vinifera* stock. The Berger is an exception. From fresh material, M. F. Bradshaw. Compare Plates XIX–XXII, and XXIV.

PLATE XXIV:

California disease. Diseased leaves of a wild species of *Vitis* common in southern California. From material gathered in 1887 by F. L. Scribner, in the Santiago cañon, east of Orange. Typical of the effect of the disease on most of the native species of *Vitis*. The virulence of the disease is well shown in its effect on the California species. For the effect upon the fruit see Plate VIII. Compare also Plates XIX–XXIII. R. Cowing.

PLATE XXV:

California disease. Canes from badly diseased Muscat of Alexandria vines, vineyard of J. A. Scarritt, Orange. From fresh material, M. F. Bradshaw.

Figure 1 shows the entire growth of one cane on a badly diseased vine for the season of 1889. The internodes are short and assume more acute angles with each other than normally. The leaves fell before the cane was ripe. The only ripened wood of the cane is close to its base on one side. The end of the unripened cane is turning black and dying.

Figure 2 shows the basal part of a larger cane having the typical uneven ripening of diseased canes. The ripe wood occurs in limited spots with intervening unripened portions. Along the margin of the ripened wood is a dark line characteristic of the disease and resembling the similar line between blighted

and unblighted wood in case of pear blight. The black spots on the green wood are of a gummy nature. The fall of the leaf from the end of the petiole, while the latter remains attached is indicated. The death of the petiole from the distal end is usual. The last effort of the cane to retain life and to ripen its wood is shown by the minute leaf at the left, which, however, would not attain any considerable size.

Figure 3 represents the semiripened basal part of the cane. It has assumed a dark color throughout, but the distal and lateral blackish parts are improperly ripened, and show an appearance very common on diseased vines after the leaves fall.

Figure 4 shows the small green patches of wood in the ripening tissue on diseased canes. The blackish line between mature and immature wood is shown as in Figure 2. The blackening of the pith in ripe and unripened wood is illustrated at opposite ends of this cane. The black gummy specks found alike on ripe and unripened wood are shown.

CHARTS.

CHART I:

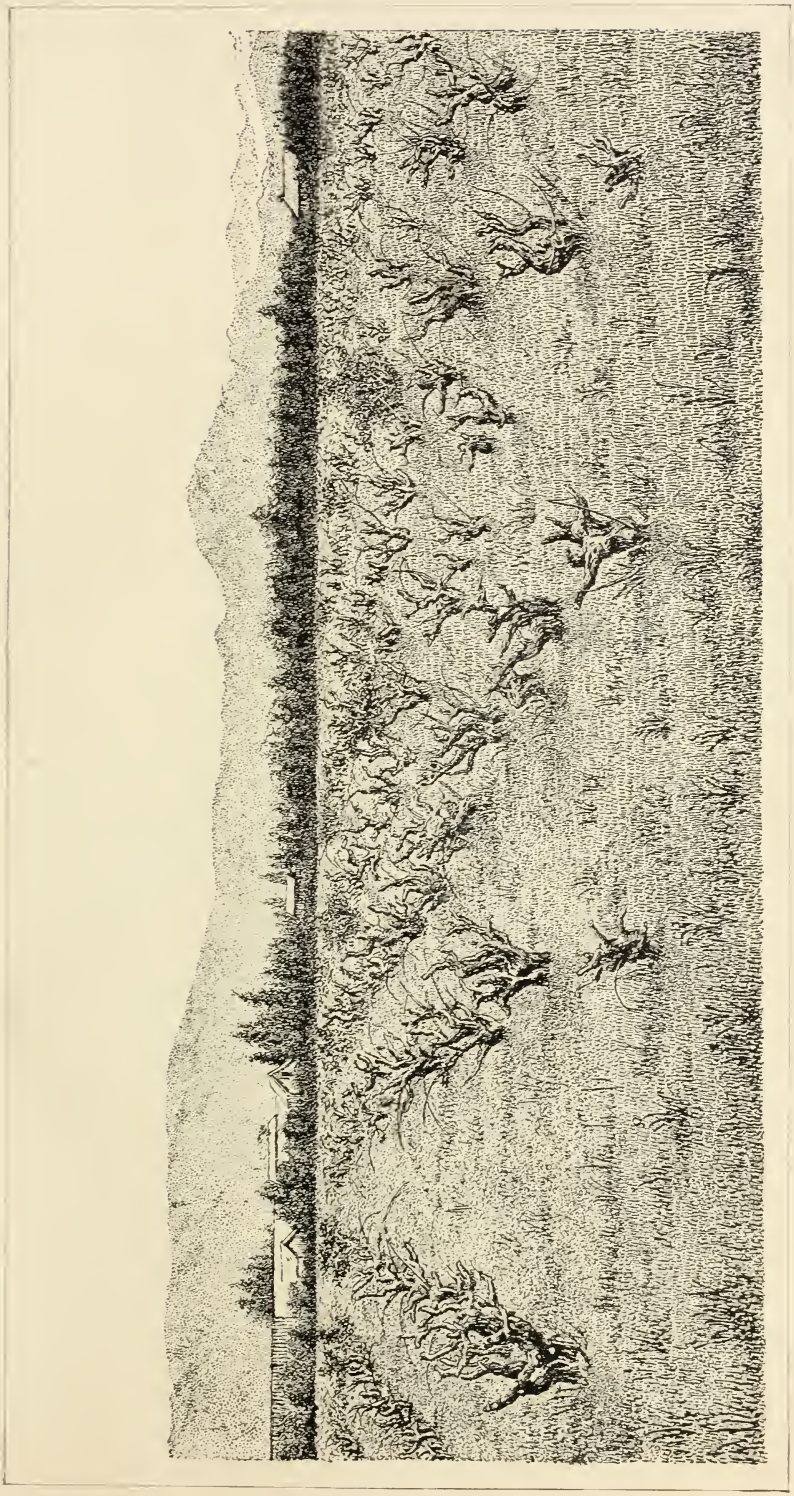
Effect of shade on diseased vines. Showing the shade effects in the vineyard of Col. J. A. Scarritt, at Orange.

See under the head of "Influence of shade." (Pp. 108–111.)

CHART II:

Plat of Anaheim, Cal. This chart of Anaheim and vicinity shows many of the old vineyards where disease was first noted, and gives full notes on the variety of grape, the date when vines were set, when disease appeared, when the vines died, and when they were removed from the ground. A full description is to be found in this report under the head of "Death of the vines at Anaheim." (Pp. 60–65.)

MUSCAT OF ALEXANDRIA VINEYARDS NEAR SAN DIEGO, CALIFORNIA.



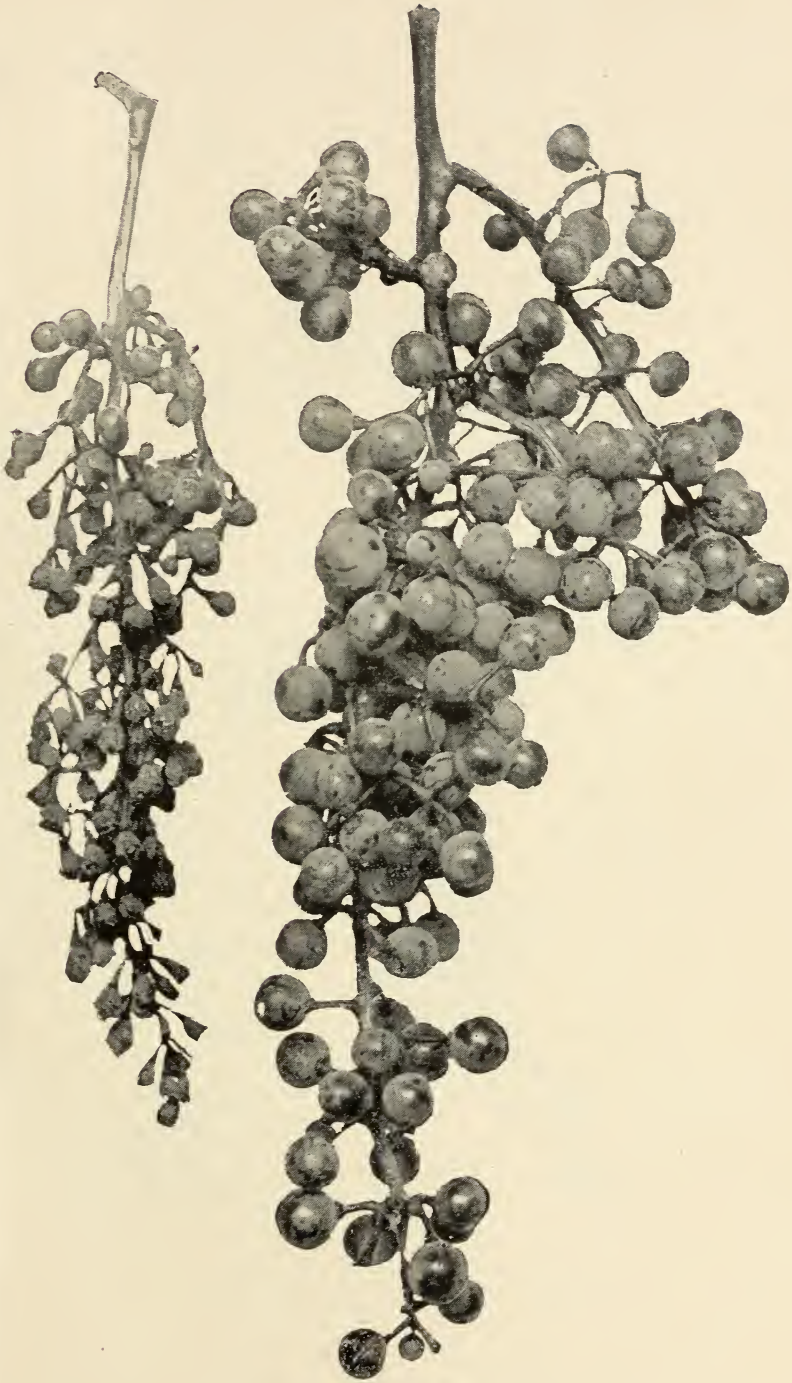
OLD MISSION VINEYARD, LOS ANGELES, CALIFORNIA.

BERGER VINE, SHOWING ACTION OF DISEASE.

MUSCAT VINE IN SECOND AND THIRD YEAR OF DISEASE.

VINE IN LAST STAGE OF DISEASE.

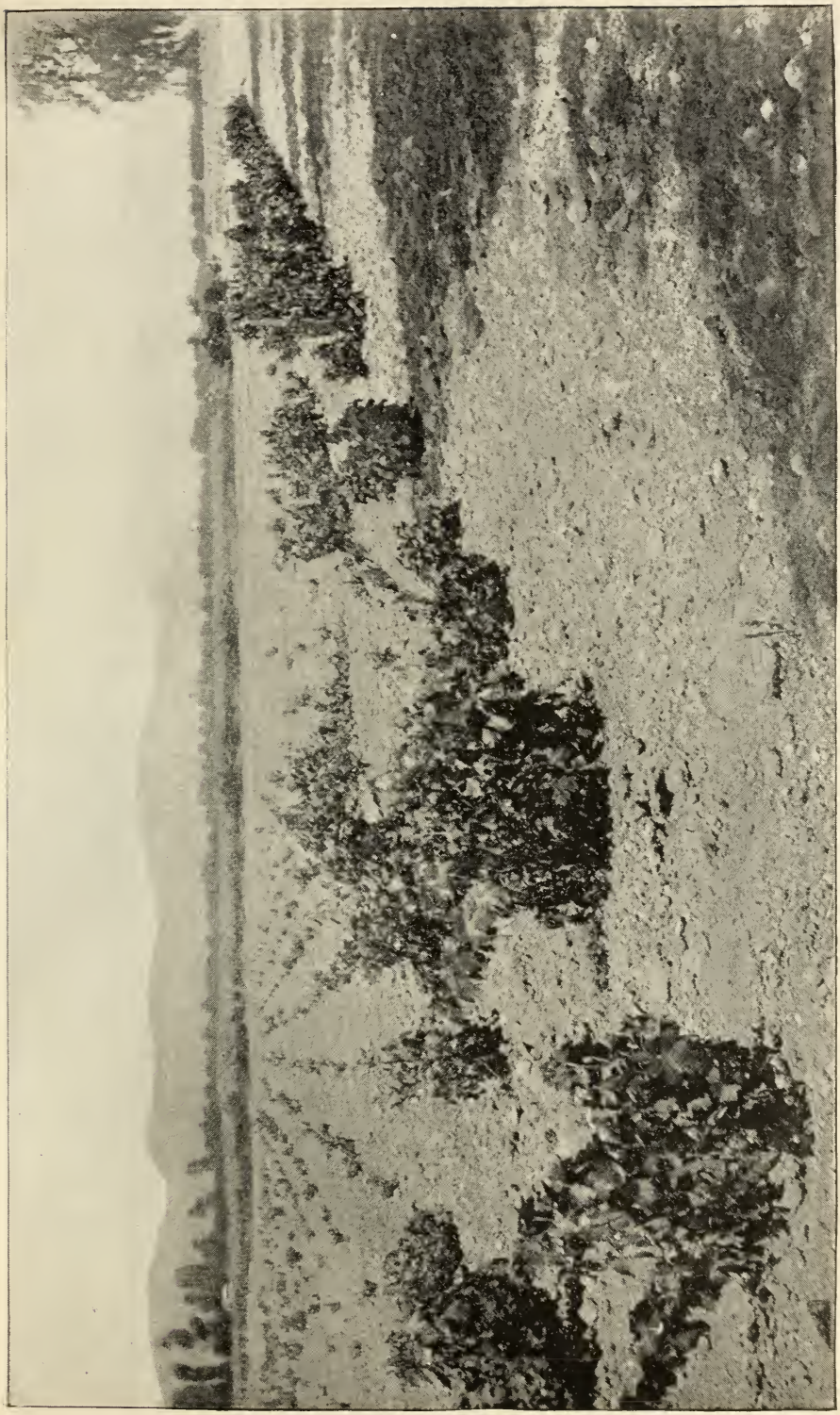
HEALTHY AND DISEASED BERGER GRAPES.



HEALTHY AND DISEASED GOLDEN CHASSELAS GRAPES.

DISEASED LENOIR AND VITIS GIRDIANA GRAPES.

PART OF MUSCAT VINEYARD COVERED BY SEDIMENTARY DEPOSIT.



MUSCAT VINEYARD SHOWING EFFECTS OF SHADE.

MUSCAT VINEYARD SHOWING EFFECTS OF SHADE.

DISEASED MUSCAT VINE.

DISEASED VINE AT ANGRI, ITALY; FIRST STAGE.

DISEASED VINE AT ANGRI, ITALY; SECOND STAGE.

FOLIAGE OF DISEASED VINE AT ANGRI, ITALY.

DISEASED VINE AT DUVIVIER, ALGERIA.

TYPICAL EXAMPLE OF FOLLETAGE FROM MILAZZO, SICILY.

TYPICAL EXAMPLE OF FOLLETAGE FROM MILAZZO, SICILY.

LEAVES SHOWING FOLLETAGE FROM SICILY.

VINE LEAVES FROM ANGRI, ITALY.

M.F. Bradshaw.

DISEASED JACQUES LEAVES FROM CALIFORNIA.

M. F. Bradshaw.

CHAS. HART & SONS, LITH.

DISEASED FLAMING TOKAY LEAVES FROM CALIFORNIA.

M. F. Bradshaw.

DISEASED MUSCAT OF ALEXANDRIA LEAVES FROM CALIFORNIA.

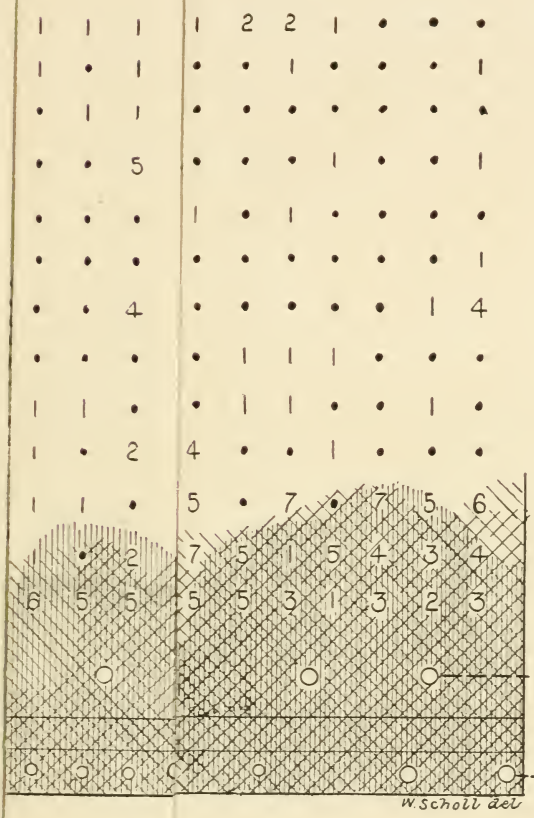
R. Cowing.

CHAS. HART & SONS

DISEASED LEAVES OF WILD VITIS FROM CALIFORNIA.

DISEASED CANES FROM MUSCAT OF ALEXANDRIA VINES, CALIFORNIA.

CHART I.

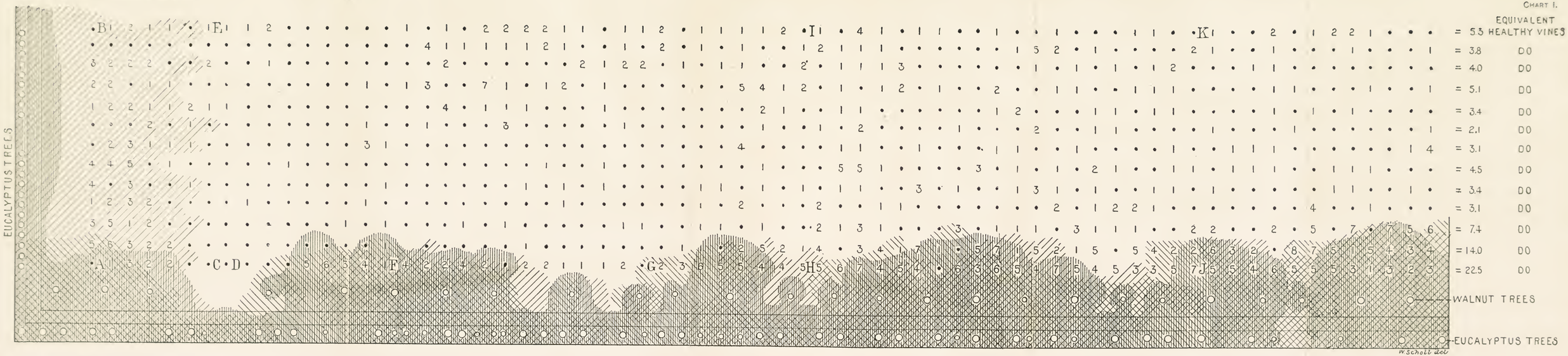


ATURE MAINING IN THE VINE.

RD OF COL. J. A. S
aken June 15, 1889.

Bull. 2, Div. Veg. Path. U. S. Department of Agriculture.

CHART I.



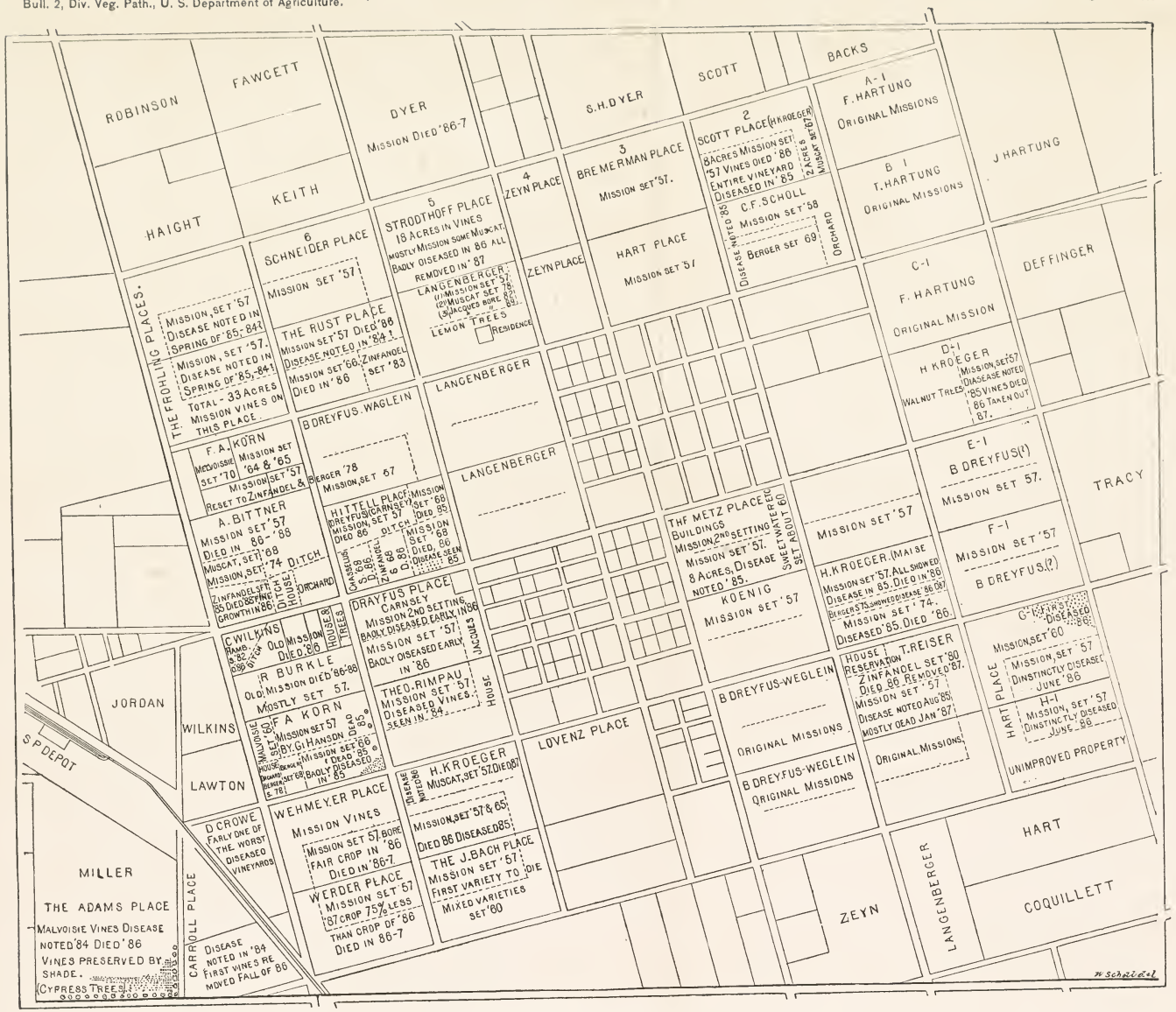
SHADE 3.30 P.M.
SHADE 8.30 A.M.
FOLIAGE LINE.

A TO K = PLACES WHERE SOIL TEMPERATURE WAS TAKEN SEE TABLE

1, 2, 3, 4, ETC., = 10, 20, 30, 40 %, ETC., OF VITALITY REMAINING IN THE VINE.
• = DEAD OR NEARLY DEAD VINES.
O = SHADE TREES.

VINEYARD OF COL. J. A. SCARRITT, ORANGE, CALIFORNIA.

Chart showing shade effects on diseased vines of the Muscat of Alexandria variety. Record taken June 15, 1899. Also, the relations of soil temperature to the disease. For a study of this chart see under head of "Shade" and "Temperature."



PLAT OF ANAHEIM, CALIFORNIA.

Chart showing many of the former vineyards; dates when the vines were planted, when they showed disease, and when they died or were removed, are given. The name of the variety of the vine is often given. The lots of the size of lot "A–1" contains 20 acres. The names of individuals given are not always those of present owners, and are presented simply as a means of reference and identification. The divisions and other characters of the chart are self-explanatory. For a study of the chart see under "Development of disease at Anaheim" and other heads.

INDEX.

N.

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P.

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