Fungus diseases of the grape and other plants and their ...

Frank Lamson Scribner

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D. Lawson Scribner

FUNGUS DISEASES

OF THE

GRAPE AND OTHER PLANTS

AND THEIR

TREATMENT.

BY

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CHAPTER I.

THE ESSENTIALS FOR STUDY.

The above illustration is worthy of notice as showing the subjects and tools of the mycologist. To the left are seen a couple of the large fleshy fungi—mushrooms they are called, or, as the toad squatting at their bases suggests, "toad-stools." Toad-stools and mushrooms are true fungi, and so are puff-balls and the hard growths that one often sees attached to the trunks of trees and logs. These are fungi which all can see, and many of the kinds can be distinguished by the eye alone, but even in the study of these we must resort to the use of the microscope to discover the characters by which the mycologist classifies them.

Smaller fungi, of mushroom-like habit, are shown beyond the two larger ones.

The irregular dotted lines extending across the illustration are evidently intended to represent bacteria, the smallest, the most numerous and, as it is beginning to appear, the most important of all living organisms. We are told that bacteria cause pear blight and some other plant diseases; that they cause cholera, typhoid fever, yellow fever and a number of other diseases of man as well as some of the most dreaded diseases of our domestic animals. There are many other things told of the powers of bacteria, but suffice it to say here that

their investigation calls for the highest scientific attainments, and taxes the powers of our best microscopes.

Among the tools essential in studying fungi the most conspicuous and first in importance, is the compound microscope, seen in an inclined position to the right of the illustration. The demand for microscopes in the study of the lower plants like fungi, has caused the manufacturers to make very good instruments at comparatively low prices. Formerly only the rich and favored few could possess one of these aids to our truly limited vision, and such instruments as were produced were cumbersome and elaborate affairs, designed rather for show than for work. Now, microscopes sufficiently good for all ordinary examinations of fungi (excepting bacteria) and the internal structure of plants, may be had for thirty or forty dollars. Below on the right is a little vial for holding water or perhaps some reagent, as glycerine or alcohol. The mycologist is usually provided with several of these small bottles for holding various liquids which he may need to use. Below, to the left of the large microscope we see needles, scissors, and small scalpels for cutting minute fragments, forceps or tweezers for handling them, little cups for holding specimens in water, a small hand magnifier for examining objects before placing them under the compound microscope, and a spatula with the handle extending up across the "G," for lifting the objects out from the fluids in which they have been placed.

With this outfit one may carry on extended investigations of almost any one of the many fungi which infest our cultivated crops, and all together the cost need not exceed $35.00.

WHAT ARE FUNGI?

Fungi (plural for fungus) are plants of simple organization, and derive their nourishment from other living or dead plants, or from living or dead animals. If they feed upon living plants they are termed parasites, and the plant supporting them is called the *host-plant;* if they get their food from dead organic matter they are called saprophytes. They have not the power of assimilating food from the soil, or from inorganic material, as do the higher plants with which we are more familiar, but their nourishment must be prepared for them ready for use. They bear no flowers or seeds, but their reproduction is effected by special organs which are termed *spores.* The vegetative portion of a fungus—the part corresponding to the root stem and leaves of higher plants—consists of slender, thread-like tubes, standing singly or more or less matted and grown together, and collectively termed the *mycelium.* The single threads are called *hyphæ*, and the branches which bear the spores are designated *sporophores* or spore-bearers. Although the fungi which attack our cultivated crops, such as the smuts, rusts, mildews, moulds, etc., are of microscopic size, there are many others of the same class which grow to considerable proportions; such are the mushrooms, "toad-stools," puff-balls, etc. These are all fungi, all have their vegetative system composed of mycelium, all feed upon organic matter, either living or dead, and all are propagated by spores. The number of plants which are reproduced by spores greatly exceeds those which bear flowers and grow from true seeds; to say of a plant that it is a fungus is a broader

and less definite expression than to say that it belongs to the class bearing flowers and seeds. It is easy enough to understand what is meant when we are told that our potatoes, for example, are being destroyed by the potato bug. To be told that they are being destroyed by the potato fungus ought to convey just as clear and definite an idea. In the case of the bug we have an insect, visible to the naked eye, and we are able to see it devouring our plants. In the case of the fungus we have a plant too small to be seen without the aid of a microscope, and whose depredations are carried on in the interior of the potato, and in a way which we cannot follow, but the processes are as positive in one case as in the other, and in both the results are apparent enough. The fungus breaks down the tissues of the plants and causes the potatoes to rot, the insect devours them.

In point of numbers the fungi which infest our cultivated plants vie with the insect tribes, and the extent of the losses they occasion is no less great; their metamorphoses are equally complex and far more difficult to follow. Their minuteness calls for the greatest amount of patience in their study, and in spite of all our efforts many points in their natural history must be left to conjecture. Let it be kept in mind that whenever and wherever a fungus appears it is as certain that its growth proceeded from a spore as that the oak came from an acorn, and that growth in the one case as in the other was induced by special favoring conditions.

The various ways in which parasitic fungi injure their host-plants may be summarized as follows: (1) They deprive them of nourishment; this is by far the most

important and general injury which is produced upon plants by parasitic fungi. (2) While the food supply of the plant is reduced, its power to replenish it is at the same time impaired, i. e., in case the fungus grows upon the green parts, as it does most frequently. (3) Growth may be abnormally accelerated or retarded, and both these effects may be produced in different cases by the same fungus, thus causing distortion. (4) Not only are the green parts affected, but roots, stems, inflorescence, flowers and fruit. (5) Leaves and fruit, when diseased, fall prematurely. (6) Many fungi cause decay of ripe fruit, both while attached to the plant and after removal while still alive.

Many valuable plants are liable to injury by infection from plants of less value which serve as host-plants to the fungus during a certain period of its development.

This very general and brief explanation of what fungi are may help us to better understand the following chapters wherein we shall attempt to describe the characters and habits of these plant-pests.

CHAPTER II.

BLACK-ROT OF GRAPES.
Laestadia Bidwellii.

Forty years ago there appeared in the vineyards of Southern Ohio a disease which destroyed the grapes to a notable extent. This disease has come to be feared above all other enemies of the vine throughout the grape-growing States east of the Mississippi and even westward into Kansas and Texas, and is everywhere recognized as *the black-rot.* A malady so devastating in its effects has naturally been the subject of many communications to our horticultural and agricultural journals, and many speculations as to the cause and many methods of treatment and so-called cures have been frequently published. The cause is a special fungus (a fact determined by the late Dr. Engelmann of St. Louis, Missouri, a quarter of a century ago) the habits and characters of which are now almost as well understood as are its effects.

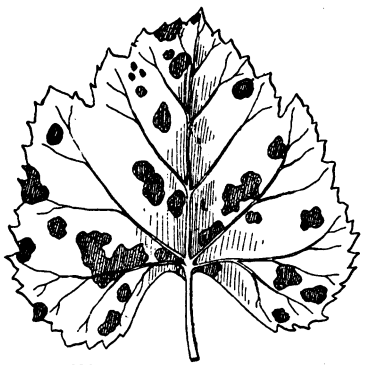

Fig. 826. Showing effect of Black-rot fungus on the grape leaf.

In considering fungi we must bear in mind that although they may be microscopic in size, each species possesses characters peculiar to itself, having as distinct an individuality as the plant or vine upon which it

may grow. As has already been stated, those feeding upon living animals or plants are termed parasites, while those which feed upon dead or decaying organisms are termed saprophytes. There are many fungi which are parasitic for a time, becoming saprophytic in the later stages of their development.

This double role appears in the fungus of the black-rot; at first it is a true parasite, occupying the living tissues of the berries or other parts attacked, but the completion of its development takes place within tissues which are shrivelled and dead; it is then simply a saprophyte.

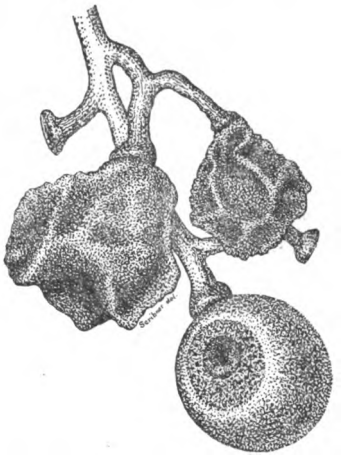

Fig. 250. Grape berries destroyed by Black-rot.

Let us examine the minute characters of this fungus and, as we proceed, note the effects or alterations in the vine which result from its attacks. These external changes or alterations constitute the diseases of which the fungus is the cause, a distinction of terms which should be kept in mind. The vegetative portion, or plant proper, of the little fungus which causes black rot, is composed of slender, colorless filaments or threads, collectively termed the mycelium. These filaments vary in diameter from one to five micromillimeters (one micromillimeter = one twenty-five thousandths of an inch), are filled with a finely granular

substance and are much and very irregularly branched. (See Fig. 1415.) They grow between, and even penetrate, the cells composing the tissues, imbibing from the juices of the host the nutriment they require. The changes effected in the host plant are entirely due to the growth and activity of this mycelium. In the leaf it causes well defined reddish brown spots of varying size, usually rounded in outline, and dispersed on the parts between the principal nerves (Fig. 326.) These spots usually appear some days or even a week or two before the berries are attacked. On the young shoots and leaf-stalks it effects characteristic changes in the form of elongated, very dark brown or black spots, which are slightly depressed owing to the absorption of the juices from the cells composing the underlying tissues, over the surface of which the characteristic pimples or pustules are more or less thickly scattered. These spots usually appear near the growing tips, but they sometimes occur on rapidly growing canes a foot or more below the apex. It is upon the berries, however, that the changes are most marked and of the greatest economic importance, as the injury arising from the attacks upon the leaves and young shoots is comparatively insignificant. In seasons favorable to the development of the fungus, that is, when there are frequent rains followed by hot, sultry weather, or when there are

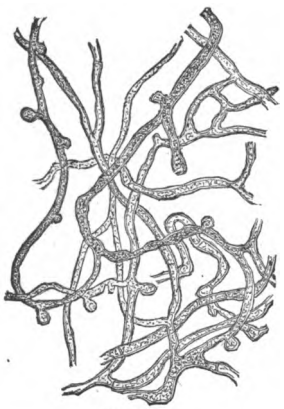

Fig. 1415.

heavy dews and fogs with a considerable range of temperature between night and day, the loss occasioned by its action on the fruit often amounts to one-half or two-thirds of the crop; in severe cases the destruction is sometimes complete. How long the mycelium of the fungus may grow within the berries without producing any external sign of its presence has been definitely determined by artificial cultures to be from eight to twelve days; in nature the period between the moment of infection and the outward manifestations doubtless varies with the conditions of temperature, moisture, etc.

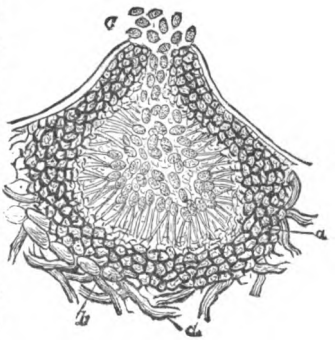

Fig. 1417.

With a good microscope it is an easy matter to see the mycelium in berries attacked by the parasite. The contents of the cells of such berries first turn brown, the cells themselves soon lose their turgescence until finally the entire berry becomes dry, hard and black. It is shrivelled to one-half or one-fourth its original size and the skin is raised into prominent, irregular ridges which are especially characteristic of this form of rot.

While the berry is yet only in part destroyed, the mycelium forms little rounded masses at numerous points just beneath the epidermis. These little masses are destined to become little cavities or conceptacles in which are borne the organs of fruitification. They are at first colorless but gradually become darker until

maturity when they are intensely black, the mycelium around them being dark brown. Developing just beneath the epidermis or cuticle, they raise, and finally burst through the latter so that the surface of the diseased berry finally becomes studded with a great multitude of little black pimples or pustules.

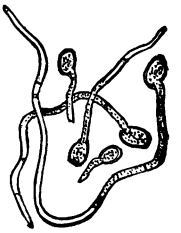

FIG. 1419.

These pimples are clearly visible to the naked eye and their presence at once distinguishes this from "brown rot," in which no such pustules appear.

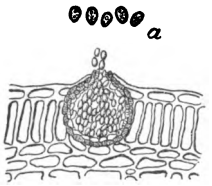

Fig. 324. Magnified view of Black-rot fungus as seen in grape leaf; *a*, spores more highly magnified.

On the diseased spots on the leaves, the pustules are generally present appearing as minute black points often quite regularly arranged in circles near the outer border of the spots.

A greatly magnified illustration of a vertical section of one of these pustules is shown in fig. 1417. The condensed growth of mycelium forms the thick black wall of the cavity or conceptacle (*pycnidium*) within which the oval spores are distinctly seen, some being attached to thin, slender stalks (*basida*), others having become detached, and others still are escaping through the opening (*osteolum*) at the top. The usual egress of

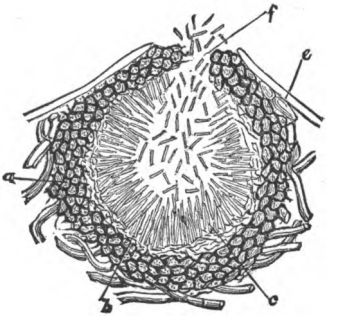

FIG. 1418.

these spores is in the form of a worm-like thread, the spores being held together by a mucilaginous substance. Water quickly dissolves this mucilage and the spores are set free. These spores, termed the *stylospores*, (see fig. 1419, stylospores germinating) afford the usual means for disseminating and propagating the fungus. They retain their vitality for a considerable length of time. They have been found to germinate in water the year following their formation.

Mixed with the conceptacles, just described, are found others, having a similar structure though generally smaller in size, containing much more minute and very slender bodies termed *spermatia*. These are illustrated in figure 1418. What may be the function of these bodies has never been clearly demonstrated. By some they have been supposed to form the male element in the process of reproduction. Others regard them as simply one of the spore-forms of the fungus designed for its propagation.

An examination of berries which have been destroyed by Black-rot and allowed to remain on the ground till the following spring, will reveal to us the mature or final stage in the development of the fungus of this disease. In the early stage of development stylospores and spermatia only are found, but now we find within the conceptacles, spores, not borne on basidia, but enclosed in elongated sacs, which are attached to the walls of the cavity (now termed a *perithecium*.) The number of spores in each sac (called an *ascus*) is generally eight. Two of these sacs are shown in figure 1420. At maturity and when freely supplied

Fig. 1420.

with moisture the sacs are broken and the spores are expelled from the conceptacles or perithecia with a considerable force. In water they germinate in a few hours. This last spore-form (called *ascospore*) is doubtless designed to insure the perpetuation of the fungus from year to year. It is not essential to the accomplishment of this, however, for, as stated above, the stylospores may retain their vitality over the winter season.

The stage in the development of this fungus in which the stylospores are produced was named *Phoma uvicola*, but when the mature form was discovered—the form by which fungi are classified—it received the name of *Physalosphora Bidwellii*, being named for Dr. Bidwell, of Vineland, N. J., to whom the honor of having made the discovery is due. By a more recent classification the fungus has been referred to the genus *Laestadia*, and it is now known to mycologists as *Laestadia Bidwellii*.

BLACK-ROT AT THE NORTH.

In the February number of *Orchard and Garden*, page 34, we announced that personal observation and reports of correspondents had led us to believe that the fungus of Black-rot of grapes did not attain the same vigor of development in the northern grape growing regions that it does farther to the south, and that the vineyardists of Western New York, Northern Ohio, Michigan and Wisconsin had far less to fear from this parasite than from the Downy Mildew which causes *Brown-rot*—the prevailing disease and the chief source of loss in that section of the country.

The Black-rot fungus being a plant, demands for itself, like other plants, a certain amount of heat or

length of season, as well as moisture, to reach its maximum development. While in New Jersey, Maryland, Southern Ohio, Tennessee, etc., it possesses the vigor of a true parasite and attacks and destroys the most healthy and soundest grapes, farther to the north it loses this vigor of habit, becoming less virulent in its attacks (excepting perhaps in some especially favorable localities) and appears only on berries which have become injured or diseased through other causes, for example, the fungus of the Downy Mildew. We do not wish to be understood as saying that Black-rot does not exist in the northern districts; it is and doubtless was present there long before vineyards were planted or even before the country was settled by white men, growing on the fruit or foliage of wild vines, (we have seen it on these as far north as Canada); but what we do affirm is that this fungus plays the part of a saprophyte rather than a true parasite in our more northern vineyards, and the losses occasioned by it are only secondary. Investigations made by us during the season of 1889, in Northern Ohio, under the direction of the Commissioner of Agriculture, serve only to confirm this statement.

It is interesting to note, in this connection, the report of Col. A. W. Pearson relative to his observations in Western New York (published in the *Steuben Farmer's Advocate* for August 7, 1889.) Col. Pearson found the vineyards on the west shore of Keuka Lake quite generally infested with the Downy Mildew, Powdery Mildew and Gray, or Brown, rot; but few vines were entirely free from these fungi. Black-rot was present only in a slight degree. "Passing among thousands of vines," Col. Pearson says, "I found not more than a dozen

grapes and as many leaves infested with Black-rot. * * * Gray-rot on the clusters was not universal: one vine may have 75 per cent. of its fruit infected, while the vine next in the row may be healthy or showing only partial disease. The same mildews and Gray-rot were found more general on the east shore of the lake and at several points, near the foot of ravines, much Black-rot and Anthracnose were discovered prevailing to an intensity almost rivalling that of these diseases in New Jersey, and evidencing that these fungi have been here existent in previous years." In the Seneca Lake vineyards the loss from Gray-rot and Anthracnose in the worst infested localities is estimated to amount to fully 50 per cent. Here also Black-rot was present, "but, as in the vineyards on Lake Keuka, it is evidently only just begun."

From Pearson's report it appears that in the vineyards he visited, embracing some 19,000 acres, the disease which was destroying the crop was Brown-rot and not Black-rot. In 1887, in company with Prof. Viala, we visited the same region and found there at that time all the diseases seen by Col. Pearson. That year, however, the season was unusually dry and the vines were comparatively free from fungous diseases. Only here and there did we find a single berry or cluster attacked, and it was the Brown-rot which was most common. We found Black-rot present in the vineyards on the west shore of the lake and at Pleasant Valley, but chiefly on berries injured by insects or already invaded by the Peronospora. As we have just stated, Brown-rot was the chief pest, and it appears to us that the observations made by Col. Pearson add confirmation to our theory that in the North the enemy which grape-growers have

most to [illegible] this disease and not Black-rot. It is only farther [illegible] the South the latter fungus assumes its strictly parasitic habits, and where it has gained for itself the title of a "veritable scourge." Although Mildew, by attacking the berries, is evidently a most serious pest in the northern regions, it will be gratifying to the grape-growers of that section to know that this alone is to be dreaded, Black-rot holding a secondary or, perhaps, an entirely unimportant position. With only Mildew to contend with, they will feel less apprehensive, for all have now learned that this disease may be readily overcome by applications of the sulphate of copper solutions.

TREATMENT.

The season of 1888 will be memorable in the annals of American viticulture for the discovery of a successful treatment of Black-rot. This disease, which for so many years has ravaged our vineyards, driving many with empty pockets from the business of grape-growing, and preventing many others from engaging in the work, has at last been overcome by methods which are practical and which may be performed by any intelligent grape-grower.

These methods consist in spraying the vines a number of times with a preparation of sulphate of copper and lime, known as the Bordeaux mixture. There are several preparations of sulphate of copper which, properly applied, will prevent mildew. The Bordeaux mixture will do this and at the same time prevent that worse disease—Black-rot.

It is *indispensable to success*, however, that the first application should be made *early*. As soon as the first

leaves appear is time to begin operations. Make the first application then; follow this with a second just before the vines begin to bloom and another immediately after the flowering period.

The number and frequency of subsequent treatments will depend on the season and to some extent also on the varieties to be treated. In seasons favorable to the disease, they should follow each other at intervals of from 12 to 15 days, until the berries begin to color. The first three treatments ought never to be neglected wherever the grapes have suffered from the disease, no matter what the character of the season may be. In addition to this, wash the vines, just before the buds begin to swell in the spring, with a strong (50 per cent.) solution of sulphate of iron. This should certainly be done if the vines are subject to anthracnose or have previously been affected with the rot; in any case this treatment will destroy many spores of fungi that may be resting on the stocks or concealed in the crevices of the bark.

The formula of the Bordeaux mixture is as follows:

In 4 or 5 gallons of hot water dissolve 8 pounds of sulphate of copper; in another vessel slake 10 pounds of the best quicklime in 6 or 8 gallons of water. When the copper solution and the lime mixture have cooled to the temperature of the air, pour the latter slowly *through a strainer* into the former, mixing them thoroughly by constant stirring. When ready to use, the mixture should be made up by the addition of water to 22 gallons. It is one of those medicines which must be "shaken before taken," and it should also be strained before going into the spraying pump. A patent flour

sieve is one of the best things for straining the lime mixture. The Eureka Sprayer is provided with a strainer for this purpose. After this double straining there is little danger of clogging spraying nozzles. The pump should have attached a Vermorel, Japy or a Vigoroux nozzle, either of which is so made that they can be quickly cleaned when obstructed by any particles of lime or dirt. The spray should reach all parts of the vine, and particular care must be taken to reach the flower clusters and young fruit. With a sprayer like the Eureka or like those now made in France, this can be done very quickly and effectively; the operator can keep moving constantly along the rows as he works. The pump is worked by the right hand, the spraying directed by the left, while the liquid is carried on the back in a tank. For the use of other copper compounds in treating Black-rot, see next chapter.

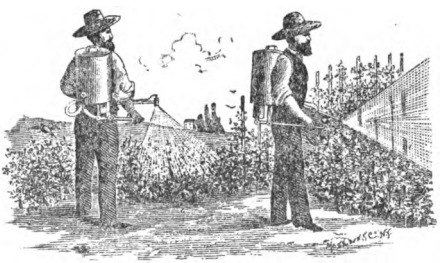

Fig. 1503. SPRAYING VINES.

SELECTION OF VARIETIES AND BAGGING.

As all vineyardists know, there are certain varieties of grapes less subject to the attacks of the Black-rot fungus—less "susceptible" to rot—than others, and so far as it is practical to do so, they will, in making up their vineyards, select the varieties most resistant in their respective localities.

In very small vineyards it is possible to protect grapes from the rot by bagging or enclosing the bunches as soon as the berries are "set"—or even while yet in bloom—in paper sacks. If put on thus early the "bagging process" will insure a perfect crop under ordinary circumstances. The berries ripen perfectly and color well, but they are more likely to crack at maturity and do not stand transportation so well as those not bagged.

CHAPTER III.

EXPERIMENTS IN THE TREATMENT OF BLACK-ROT OF GRAPES.

At the Cleveland meeting of the Society for the Promotion of Agricultural Science, we briefly announced the success of the experiments made at Vineland, New Jersey, in treating Black-rot of grapes by applications of solutions of sulphate of copper. The results that were there obtained with Bordeaux mixture conclusively demonstrated that by the proper application of this compound we may successfully combat the most terrible scourge of the vineyardist—Black-rot.

The applications were made with the Eureka Sprayer May 29, June 4, 21, July 2 and 11; the variety selected for treatment was the Concord. On the untreated vines rot appeared on the leaves June 8, on the fruit June 27, and by July 15 more than three-fourths had been destroyed by the disease. There was no sign of rot on the vines treated with Bordeaux mixture previous to July 20. Soon after this date these vines showed some signs of rot, particularly on bunches that were hidden under masses of foliage where the spray could not easily reach

them; the most exposed bunches—those most readily sprayed—remained wholly free from disease.

By July 30 there was considerable rot on treated vines, evidently the result of a recent attack, as none of the diseased berries were yet blackened or shrivelled. On the untreated vines one could scarcely find a bunch with more than a half dozen sound berries in it. Knowing as we now do, that the period of "incubation," or the time from the moment of infection to that when the disease becomes externally manifest, is from 8 to 12 days, we conclude that this attack of the treated vines occurred about 10 days after the last application was made. In making the applications, no care was taken to spray the clusters; the foliage was very thoroughly sprayed, however, and of course the bunches received more or less of the mixture; those clusters which were concealed by the foliage received the least, and, as stated, these were the first to show signs of rot. Had special care been taken to spray the bunches, and had another application been made about July 17, we believe, from what was really accomplished, that the protection would have been complete and the loss from rot practically nothing.

Col. Pearson, who had charge of and personally conducted the experimental work at Vineland in his own vineyard, noted two well-marked periods of attack, one about June 22, becoming manifest June 27, and another July 18 or 19, becoming apparent July 26. The first period was detected through having bagged the clusters on successive rows of vines, extending the work of bagging over a number of days. On July 30 an examination of those bagged on or before June 21 showed

them to be entirely free from rot, while those enclosed in bags after that date were more or less diseased. The vines sprayed with the Bordeaux mixture *entirely* escaped this first attack. It is interesting to note that they were sprayed June 21. Had this spraying been delayed for a couple of days, the results might have been quite different, for the spores of the fungus, then especially active, would have had time to germinate, penetrate the skin of the berry, and gotten beyond the reach of the fungicide. This is not pure speculation, but a conclusion drawn from a knowledge of the habits of the fungus.

The following experiments made by Col. Pearson are interesting in this connection: Clusters of grapes bagged before June 21, were unbagged August 1 and left exposed for a few days, and then sprayed with the Bordeaux mixture. Within a week these clusters showed a few rotten berries; these were picked off, and up to August 27 no further indications of disease had appeared. About the middle of August a number of clusters were unbagged and sprayed *at once*, others were unbagged and left without spraying. The former were, on August 27, sound, while on the latter rot specks were appearing. This experiment gives additional and seemingly conclusive proof of the efficacy of Bordeaux mixture in combating Black-rot.

Mr. John Hertlein of Spielerville, Logan Co., Arkansas, reports successful treatment of Black-rot with the simple solution of sulphate of copper. He made three applications, April 18, May 2 and May 30. Four hundred vines, embracing several varieties, were treated. A row through the middle of the vineyard was left untreated to serve as a check to the experiments.

Strength of solution used at first application was 1 lb. to 20 gallons. This burnt the foliage of Ives, Norton's Virginia, Mo. Riesling and Berckmans, but not that of Delaware. Strength of solution in the second and third applications was 1 lb. to 30 gallons. Even at this strength the foliage of four varieties was injured when the applications were made in the morning. No injury resulted to the foliage when applications were made in the evening.

Black-rot was first seen May 26. By the first of July the difference between the treated and untreated vines was very marked—very little rot on the former, while the latten were badly rotten. The varieties were not all alike protected by the applications. There was no visible difference between treated and untreated Berckmans and Vergennes, both rotting equally, while the difference between the treated and untreated Concords was very striking; the former yielded at the harvest (Aug. 6) 10 lbs. on an average per vine, the latter only 3½ lbs. Mr. Hertlein concluded by saying that he has entire confidence in the remedy (simple solution of sulphate of copper).

From what the experience of the present season has taught us, we expect to be able to indicate a course of treatment for Black-rot of grapes which will be economical, practical and efficacious. We think it may safely be asserted that the Bordeaux mixture, properly applied, is a certain preventive of the disease.

AN EXPERIMENT IN THE TREATMENT OF BLACK-ROT IN FRANCE.

(A Report Made to the French Minister of Agriculture, by M. Prillieux, Dated at Paris, July 28th, 1888).

The disease of the vine which has long been known in America as "Black-rot," has, unfortunately for us, established itself in this country and is continually spreading. We hoped for two years after its discovery in 1885 over a very limited area in the elevated valley of Herault, that it would remain within these narrow bounds, but as early as last year I observed several new centres of the disease which were scattered here and there through the valley of Garonne, between Agen and Aiguillon, in the elevated valley of Lot, beginning at Figeac and also in that of the Tarn near Millan and of St. Affrique.

This year it has been observed near the fine vineyard of Aigues-Morte by the side of Lunel, and in Gironde at Cerons, not far from Sauternes. This very morning I have discovered the existence of a new centre of infection in Charente, a region hitherto free from the disease, having received specimens showing the positive characteristics of Black-rot upon grapes and leaves from Chazelles.

If one has witnessed the terrible losses caused by Black-rot and seen how rapidly it destroys an abundant crop, he cannot refrain from having grave fears for the future, although for the present the disease is confined to a few isolated points.

In the reports which I had the honour of addressing to the Minister of last year—after having visited the

vineyards where Black-rot had appeared—I drew special attention to the early date of the attacks of the disease upon the leaves. From the leaves the spores are scattered upon and infect the berries, and with this in view I expressed a wish that the experiments of treatment might be commenced in good season and followed out with care and patience.

A small infected area situated at Aiguillon in Garonne at the mouth of the Lot, and badly diseased since 1885, seemed to me to be particularly adapted for use as an experimental field for trying the remedies.

M. Despeyroux, the proprietor of the vineyard, consented to give his assistance to all the experiments I wished to undertake. M. Lavergne, a pharmacist at Aiguillon, offered to undertake the personal supervision of all the experiments which I should indicate to him. You yourself were willing to grant me (under conditions which should be exactly determined) the necessary funds to ensure the testing of the tried remedies for Black-rot.

In the fall of 1887 while the berries that had been dried up by Black-rot were still hanging to the vines, I asked M. Lavergne to take the first steps in the plan which I had adopted for M. Despeyroux's vineyard, by carefully marking all the diseased vines. After obtaining these exact data I could organize the plan of my experiments for the following spring.

The part of the vineyard reserved for the test comprised eleven successive rows each containing fifty vines.

Three rows (6, 7, & 8) traversing the midst of the infected area were reserved as a check lot and not treated.

The three following rows (9, 10, & 11) were treated with Bordeaux mixture. In the first two treatments (May 22nd and June 22nd) the mixture was made with different degrees of strength for each row; for the first, (row 9) 15 lbs. sulphate of copper, 30 lbs. lime, to 22 gallons of water; for the second (row 10) 13 lbs. sulphate of copper, 13 lbs. lime; for the third (row 11) 6 lbs. sulphate of copper, 4 lbs. lime. In the last two treatments made July 2nd and 19th, the strength of the mixture was the same for each row—13 lbs. sulphate of copper and 13 lbs. lime to 22 gallons of water.

The three rows situated on the other side of the check rows were also treated, the first two (3 and 4) by eau celeste, containing 2 per cent of sulphate of copper for the first two treatments, and 3 per cent for the last two.

Finally, upon the last two rows (12 & 13) in the plot, different powders were applied: for the first two treatments, cupric steatite, carrere powder, and a mixture of 1-10th sulphate of copper and 9-10ths triturated sulphur; and Bordeaux mixture, composed of 13 lbs. sulphate of copper and 13 lbs. lime, for the last two treatments.

Black-rot spots on the leaves were distinctly seen June 8th, but only on the untreated rows. Under the influence of a constantly moist environment, the disease progressed in spite of the first treatment, and by June 18th, the leaves were everywhere attacked, but in very different degrees. In the check rows scarcely a leaf was intact; in the treated rows, especially those treated with Bordeaux mixture, the diseased spots were very rare.

The applications were repeated on several occasions.

The first attack on the grapes occurred July 12th,

when some of the berries on the untreated vines showed the disease. July 13th, the three check lots were everywhere attacked and the disease had invaded some clusters in the treated portions. Under the influence of constant moisture and a somewhat warm temperature the disease made terrible progress. By the 16th, the crop on all the untreated vines was lost, but the treated vines, especially those having received the Bordeaux mixture, were resistant. Another application was made July 19th. At this date the diseased berries, which up to this time had been reddish-brown, became covered with fruiting pustules of the parasite and assumed the black color and wrinkled appearance that is so characteristic of the disease.

M. Lavergne carried the entire experiment through with a painstaking precision in all its details. The number of healthy and more or less diseased berries was exactly noted for each of the 500 vines. I shall at a later time have the honor of presenting a full account of my researches, but I wish to acquaint you without delay with some of the more striking features which were apparent on the examination of July 25th.

In the three rows of untreated vines the fruit was completely destroyed, as is shown by the following figures:

Row 6 (check)—10 per cent. healthy,—90 per cent. diseased.

Row 7 (check)—2 per cent. healthy,—98 per cent. diseased.

Row 8 (check)—0.23 per cent. healthy,—99.77 per cent. diseased.

The contrast with the following rows treated by Bordeaux mixture is very striking:

Row 9—86 per cent. healthy,—14 per cent. diseased.
Row 10—78 per cent. healthy,—22 per cent. diseased.
Row 11—75 per cent. healthy,—25 per cent. diseased.

The treatment with eau celeste was efficacious, but in a less degree; in the third row, where the best results were produced, there were 42 per cent. healthy and 58 per cent. diseased grapes. In the next row, the proportion is 25 per cent. of the healthy, to 75 per cent. of the diseased, but it should be mentioned that this row was badly attacked by the Anthracnose, and its ravages may have been partially confounded with those of Black-rot.

The simple solution (two or three per cent. solution of sulphate of copper) gave only very moderate results, the proportion being fifteen healthy to eighty-five diseased berries. The powders also gave very little satisfaction since they were subjected to incessant rains.

In a future report I shall have the honor of presenting and discussing the numerous data furnished by this experiment. It demonstrates with perfect certainty the fact, long suspected but not positively established either in France or America, where the disease has ravaged the vineyards for several years, that Black-rot as well as Mildew may be arrested by copper treatments if the applications are made at the proper time and in the right manner.

The success of the experimental treatment at Aiguillon in a year when the atmospheric conditions were so exceptionally favorable to the disease, as is shown by the total destruction of the crop on the untreated vines, is a certain assurance of future success, and we are safe in concluding that we may combat Black-rot by the same means that we do Oidium and Mildew.

In a later report to the French Minister, M. Prillieux detailed the results from the experiments made at Aiguillon, from which we make the following extracts:

It clearly appears from the experiments made at Aiguillon that the sulphate of copper treatments, particularly the Bordeaux mixture, afford an effective means of combating the dreaded Black-rot.

It is especially important to carefully collect and

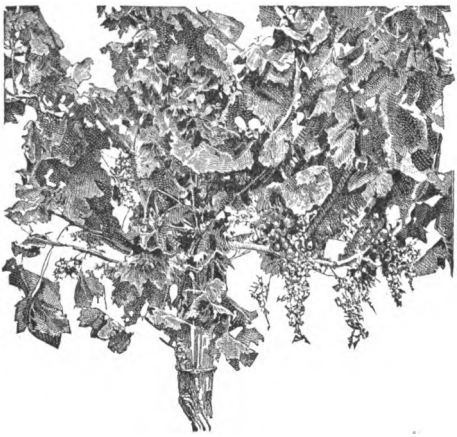

Fig. 1567. A PORTION OF VINE ATTACKED BY BLACK-ROT AND NOT TREATED.

destroy, in the autumn, all the berries dried and blackened by the disease, for we know that it is upon these that the special fructifications designed to propagate the fungus another season, are developed during the winter. The berries which have fallen to the ground must not be overlooked, and while we cannot expect to destroy all the infectious material, we can greatly diminish the chances for the reappearance and spread of the disease the following season, and render more easy and

more complete the success of the copper treatments. * *

Wherever Black-rot has appeared the year previous, the first preventive treatment with the Bordeaux mixture should be made during the latter part of May, renewing the applications as soon as the characteristic spot appears on the leaves. * * * * * *

The year 1888 has been unusually damp, and conse-

Fig. 1568. A portion of vine treated with the Bordeaux mixture.

quently favorable to the development of fungous diseases; it is natural to suppose that another year Black-rot will be less prevalent or rather less severe in its attacks, and more easily combated. We may, I think, confidently hope that where we destroy as completely as possible the diseased berries and make the preventive applications of the sulphate of copper compounds in good season, the losses from Black-rot will be very considerably reduced, and this new disease (for France)

will cause but little damage even in regions where it has longest existed.

The best results in the experiments made at Aiguillon were obtained with the Bordeaux mixture prepared according to the original formula, i. e. with 7 per cent. sulphate of copper and 15 per cent. of lime.

M. A. de L'Ecluse, professor in the department of agriculture of Lot-et-Garonne, France, has been making carefully conducted experiments in the treatment of Black-rot of grapes, a detailed account of which is published in "*Progres Agricole*" for October 13, 1889. The Bordeaux mixture, containing 12 lbs. sulphate of copper, 6 lbs. of lime, to 22 gallons of water, gave the best and most satisfactory results, with but three applications, the first being on May 29. Prof. L'Ecluse makes the following conclusions:

1. The efficacy of the cupric compounds against Black-rot is beyond question.

2 Their uncertainty has resulted from ignorant methods adopted in their use.

3. Their action is at once preventive and curative, if the preparations are uniformly distributed over all the green surfaces of the vine.

4. The loss to the crop is diminished as the manner of execution of the treatments is more perfect.

And he adds that it is probable that two treatments will be sufficient to overcome the disease.

The illustrations, Figs. 1567 and 1568, show the appearance of the vine when attacked by Black-rot and also after being treated with the Bordeaux mixture, reproduced from the official report of M. Prillieux of France.

EXPERIMENTS IN TREATING BLACK-ROT IN 1889.

The weather during the season of 1889 was most favorable for the development of the Black-rot fungus of grapes. In June, at the most critical period, there were daily showers preceded by a very hot sun and succeeded by cool nights with heavy dews. Fungi of all kinds flourished and grapes were severely attacked by the rot. Under these circumstances the remedies employed for preventing this disease were put to the severest test, especially when such susceptible varieties as the Concord and Catawba were the subjects treated.

We have experimented this season on Concords in a vineyard located far up on a steep hillside, a most admirable exposure, good soil and vigorous vines, but which last year lost more than 95 per cent. of the crop by rot. The vineyard was therefore thoroughly infected with the disease, and this was evident enough in the spring by the many rotten berries still upon the ground and the early and abundant appearance of the leaf-spot disease on the foliage.

The preparations used were the Bordeaux mixture (8 lbs. sulphate of copper and 10 lbs. of lime to 25 gallons of water) and the ammoniacal solution of carbonate of copper (5 oz. of the carbonate and 1 quart of ammonia to 22 gallons of water). Previous to using these, the vines were thoroughly washed, March 12, with a simple solution of sulphate of iron (50 lbs. of the sulphate to 24 gallons of water). Five applications of the Bordeaux mixture and the carbonate of copper solution were made, the first on April 23, when the young shoots were from 4 to 12 inches long, and the others at nearly regular in-

tervals until June 22. August 9 there was an abundance of both preparations, still adherent, upon the foliage of the vines in spite of the frequent and heavy rains during the last fifteen days of July. So much of the Bordeaux mixture still adhered to the clusters of the then nearly ripe fruit that, as this was designed for the table and not for wine, it was feared its market value would be affected. It was in view of the possibility of this result that a sixth application, originally intended, was not made.

The leaf-spot disease, or Black-rot on the foliage, began to appear May 9, and from that date on it was quite general throughout the vineyard, although there was very decidedly less on the vines treated with the Bordeaux mixture than on those treated with the carbonate of copper solution or on those untreated; there was no apparent difference between these last and we began to doubt the efficacy of the ammoniacal carbonate of copper preparation. Later developments, however, make it evident that it is scarcely, if at all, inferior to the Bordeaux mixture.

On June 8 we found in our experimental plat a single berry affected with the rot. Between this date and June 22 was a period of showery and damp weather, like that above described, and there was a general and severe attack of the rot. The berries on the treated vines were much less affected than those on the untreated; from ten vines of the former we picked, June 22, four quarts of specked and more or less decayed berries, while we got the same amount, much more badly diseased, from three untreated vines. This was a fair comparative showing at that time. During July

a second attack took place which somewhat affected the treated grapes but by no means to the same extent as it did those which had received no applications; the latter were nearly all destroyed.

In conclusion, we may announce very briefly the results of our experiments; they are strongly in favor of the treatments. The value of the Bordeaux mixture in treating Black-rot, affirmed by us, has been maintained and we feel almost assured that the ammoniacal solution of carbonate of copper is equally efficacious; we certainly can detect no difference in the effects of these two compounds as used by us this season. The treated vines have lost a third of what might be estimated as a full crop, while the loss on the vines left untreated, for comparison, is practically complete, there being scarcely more than four or five per cent. of the berries left unaffected.

Considering the very unfavorable character of the weather; the thorough infection of the vineyard from the disease of last year; and especially the great susceptibility to rot of the variety under treatment, we deem the measure of our success highly gratifying. We cannot hope to free a vineyard from the disease in one season, nor yet in two, but we may hope, and confidently, that with each succeeding season of careful treatment, success will be more and more complete.

In seasons of great humidity, the rot will doubtless occasion some loss however diligently we may strive to check it, and in view of this, we would recommend the possessors of small vineyards who raise grapes only for the table, to use paper bags. These put on in good season are a certain protection against the rot and at

the same time prevent the depredations of birds and insects. The proprietor of the vineyard where our experiments were conducted, Mr. J. T. Allen, put on many bags while the grapes were in full bloom; in these the fruit is now perfect and finely colored.

The winter treatment with sulphate of iron we consider highly important, and another time we would employ a stronger solution, making it up to 50 per cent., and, perhaps, adding to this a small quantity of sulphuric acid. The application of this to the pruned vines will be likely to destroy all the germs of disease that may be resting upon them. Unless the grapes are grown for wine we would discontinue the use of the Bordeaux mixture after the second application, as its presence on the clusters might depreciate their value, and in the succeeding treatments we would use the ammoniacal solution of carbonate of copper. Should this latter compound prove to be as entirely efficient as the Bordeaux mixture, it will be generally adopted for all the treatments, as it is less expensive and, being a clear fluid, is applied with less difficulty. The strength of the preparations as given above ought not to be reduced; we would prefer to increase the amount of copper in each rather than diminish it.

CHAPTER IV.

BITTER-ROT.

For a number of years past vineyardists in some sections of the Eastern States have recognized a form of grape-rot under the name of Bitter-rot, on account of the particularly bitter taste of the affected berries. It is probably the same disease which has been designated by some as "Greely rot," because first noticed during the presidential campaign of 1872. This name—Greely rot—is also applied to Brown-rot.

However long the disease may have been familiar to grape growers, its cause has only recently been discovered. It was in the latter part of July of 1887 while, in company with Prof. Viala, making investigations in the Tokay vineyard at Fayetteville, N. C., that we first observed the fungus which occasions the Bitter-rot. The berries were beginning to ripen and the weather at the time was hot and very damp, heavy showers occurring almost daily. It was just such weather as would favor the development of fungi, and the Bitter-rot fungus appeared to be taking advantage of circumstances by ravaging the crop most seriously. Although evidently parasitic, its attacks were most noticeable on those vines whose vitality had been weakened by a severe attack of mildew the previous year. The stalks of the bunches and their branches were often affected,

becoming dry and hard before there was any evidence of the presence of the fungus in the berries. In such cases the latter became wilted and appeared as if suffering from sun-scald.

When the berries are directly attacked, we notice first a slight discoloration on one side; this rapidily spreads over the whole berry, and the latter assumes a uniform livid brown color. So far, it remains plump

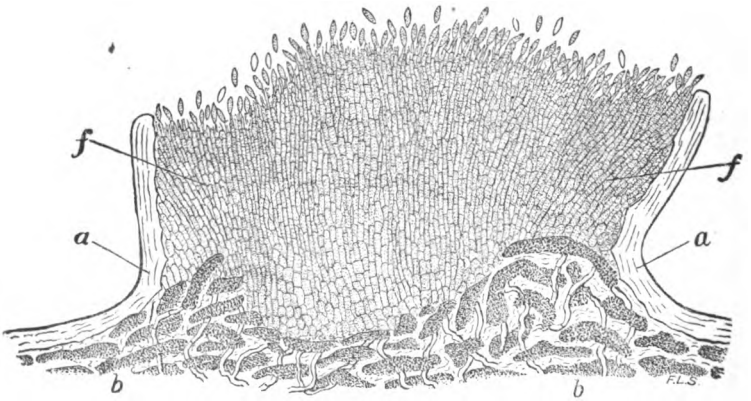

Fig. 1533. Fungus of Bitter-rot.

and is even more than normally juicy, but its flavor is intensely bitter. Soon little black or smoky colored pustules dot the surface more or less thickly, indicating that the fungus has commenced to fruit or produce its spores. These pustules are generally a little larger and more flattened than those of Black-rot, and they are usually more scattered. Presently the berries begin to shrivel, but as they quickly lose their hold upon the pedicels, they rarely dry up before becoming detached

and falling to the ground. At this stage they do not exhibit that intensely black color characteristic of Black-rot but remain a clear brown or deep purple.

If the diseased berries are examined with a good microscope at the time when the pustules first appear, the tissues will be found to be penetrated in all directions with the mycelium of the fungus. Even the seeds do not escape this growth, for the fruit of the parasite is often found upon their coatings. The illustration (Fig. 1533) shows a highly magnified section through one of the pustules. The mycelial threads (the vegetative part of the fungus) are seen in the dried and brown tissues below. Resting on this tissue and extending through the epidermis, which has been burst asunder, is a compact growth of hyphæ, smoky-brown in color, upon the outer and free tips of which the spores, similarly colored, are borne. The shape and comparative size of the latter are well shown in the figure. Sometimes these hyphæ are very short, forming, as it were, a thin spore-bearing layer just beneath the cuticle. Again, the mass of hyphæ may be broken up with cavities whose walls are lined with spores borne upon very slender, simple or branched stalks, some of which are shown in figure 255.

Fig. 255. Spores of Bitter-rot attached to their pedicels.

No other form or stage in the development of the fungus of Bitter-rot, than that above described, is at present known. Some have suggested that it was only a form of the fungus of White-rot, but although the alterations effected by both are in some respects alike, and there is a good deal of similarity in

the spores, they are entirely distinct. We have found White-rot in a few isolated localities, while we have observed Bitter-rot in a number of the Atlantic States and westward to Texas. In France and Italy White-rot is now common, while the fungus of Bitter-rot appears to be unknown. Dr. Cavara, an Italian investigator, has recently described a fungus found on grape berries in that country and which he names *Tubercularia acinorium*, that has a striking resemblance, in the figure at least, to our fungus of Bitter-rot *Greeneria fuliginea*. If it be shown that they are the same, and their identity seems not improbable, its origin will be considered American, and they will charge to our account a new vineyard pest.*

No remedy is known for Bitter-rot, but the liberal applications of fungicides made for combating Mildew and Black-rot, will doubtless lessen its ravages in the same manner as their use has, in many cases, diminished the attacks of White-rot. The fungus appears to be less parasitic than Black-rot and is therefore less likely to attack vines in vigorous health. We have yet much to learn respecting the mode of attack and other habits of this as well as of the other rot-producing fungi, and every one should remember that all observations respecting them, however unimportant they may appear to be, ought to be recorded.

* The Greeneria fuliginea has been discovered on grapes in Italy during the past year (1889).

WHITE-ROT.

In the extreme southwestern part of Missouri, and in neighboring parts of Indian Territory, a form of grape rot was discovered September, 1887, which had not before been recognized in this country. The same disease was discovered in Italy in 1878, and in France in 1885. In 1887 it had spread in the latter country to such an extent as to cause serious apprehension on the part of the grape-growers in a number of sections of that country, the loss amounting in some instances to half the crop.

The recent appearance of the disease in Europe, and its discovery in this country at points where no European vines have ever been cultivated, have led some to regard it as of American origin. The French accuse us of sending them the Phylloxera, the Downy Mildew, the Oidium and the Black-rot, and now they say that this White-rot has come from America to invade their vineyards. We cannot deny it; the evidence is too strong against us. These pests have carried devastation and often absolute ruin into the vine-growing regions of France, but that nation has set its ablest scientists at work investigating those evils, and they have in a measure overcome them in so much that now we look to French authorities for information regarding these parasites, and especially for a knowledge of the means to combat them. Our grape-growers have been "protected" from the products of the French vineyards, and we have sent enemies among them to destroy their vines, yet still they are masters of the field, and we go to them for wisdom.

The White-rot fungus attacks both the berries and young shoots, but it has not been observed upon the leaves. When the peduncle of the clusters, or its branches, are attacked, they turn brown, and the berries of the entire cluster of that portion situated near the point of attack, quickly dry and appear as if broiled by the sun. Generally, however, the berries are attacked directly, they become abnormally juicy, then they shrivel, and over their surfaces appear many small pustules, gray or sometimes more or less brown in color. The skin has the appearance of being covered with a great number of minute blisters. The berries finally become completely dried, but they do not blacken nor shrivel into the strong prominent ridges, as do berries affected with Black-rot.

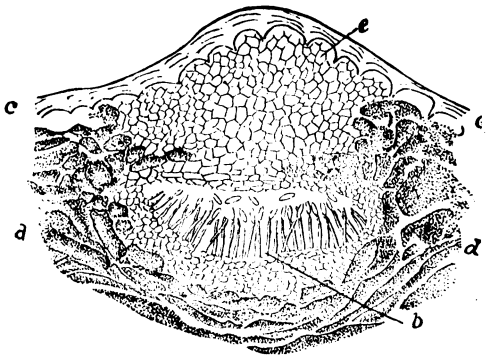

Fig. 1531. Fungus of White-rot.

A microscopical examination of the pulp of the diseased berries will reveal the mycelium of the parasite in considerable abundance. The threads of this mycelium are very fine, colorless and frequently septate. At the points where the pustules occur, the mycelium makes a special growth for the production of spores. A cushion of colorless, thin-walled cells, is first formed. This

continues to grow, raising the epidermis, and when numerous, imparting to the surface a pimply or blistered appearance. Finally there is formed in the enlarged cushion a cavity or conceptacle for the spores. These are borne on slender stalks, that are either simple or branched, springing from a delicate layer of tissue resting on the bottom of the conceptacle (see Fig. 1531). When fully mature, an opening is formed at the top by the breaking away of the fungus tissue, the epidermis having previously been ruptured, and the spores escape. The spores are ovoid in form, usually narrowed slightly at the point of attachment, and are about the size of the spores of the Black-rot fungus. At first they are colorless, but they soon become dark brown. Now that we know of the presence of this disease and its characters, it will doubtless be found in other localities than those above named. We have seen it in Washington, D. C., and have heard of its occurrence in New York.

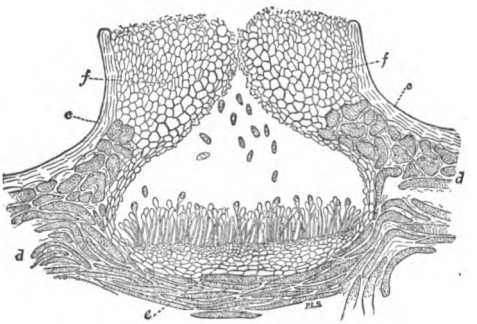

Fig. 1532. Fungus of White-rot.

No special treatment is known for this disease, but it has been reported both in this country and in France, where the disease prevailed, that on vines which had been treated with the Bordeaux mixture or eau celeste

for the mildew, there were very few berries affected with White-rot, while on neighboring vines not treated, such berries were found in abundance.

Fig. 253. Spores of White-rot germinating.

Fig. 1531 shows a vertical section through one of the pustules in White-rot, in its early or young stage, enlarged 300 diameters—*c c* cuticle of berry; *d d* dead tissues of the berry; *b* spore-bearing stalks; *e* very delicate and clear fungus-tissue which extends below the spore cavity.

Fig. 1532 represents section through one of the pustules on a grape berry attacked by White-rot, showing the manner in which the fungus produces its spores; *c c* cuticle of berry ruptured by the growth of the fungus; *e* a layer of clear tissue belonging to the fungus from which arise the spore-bearing stalks; *f f* clear tissue belonging to the fungus, composed of thin-walled cells. The heavily shaded portion *d d* represents the brown and dried tissue of the berry.

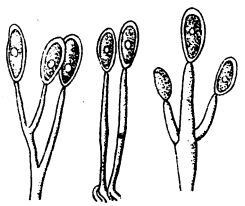

Fig. 254. Spores of White-rot attached to their pedicels.

In Fig. 254 are shown several of the spore-bearing stalks, very highly magnified, and in Fig. 253 spores of White-rot germinating.

CHAPTER V.

BROWN-ROT.

Brown-rot of grapes is caused by *Peronospora viticola* or Downy Mildew, a parasitic fungus better known from its attacks on the foliage of the vine than from its injury to the fruit, although this is by no means inconsiderable.

Aside from some of the larger fleshy fungi like the edible mushroom, *Agaricus campestris*, probably there is no species of this class more widely known than the Downy Mildew, or one whose habits and botanical characters are better understood. So frequently have accounts of it appeared in public prints, that excepting for the sake of maintaining some uniformity in these papers, and rendering them to a certain degree complete in themselves, many of the details which follow might well be omitted.

The Downy Mildew is a parasite in every way unlike the fungus of the Black-rot, except in the conditions which favor its development and in the choice of its host. Both attack all the green parts—leaves, young shoots and berries—of the vine and both thrive best in low, damp situations or during moist, sultry weather; but while the *Physalospora* occasions serious injury through its ravages on the berries, the *Peronospora* attacks with nearly equal severity both the berries and the foliage. To the vine itself, the latter is the greater

foe, for by repeated, severe attacks the fungus is sure to destroy it; to the grape grower, however, the Black-rot is the greater enemy, for it destroys his crops, and these gone, it matters little to him what becomes of the vines.

Peronospora viticola is as much a plant as is the vine upon which it feeds, and like the vine it possesses a vegetative and a reproductive system; the former is the mycelium or plant body of the fungus, the latter are the spores. Every one knows that the leaves and other parts of the vine are made up of tissues composed of cells of various structure and shapes. The *Peronospora* is also made up of cells, but of a simpler character. The plant body of the fungus is composed of very much elongated, simple, thread-like cells which collectively we term the mycelium. When one of the reproductive bodies falls upon a leaf or other tender part of the vine, and is supplied with drops of dew, it germinates, and quickly bores it way through the cuticle, takes root, so to speak, and the developing threads of the mycelium continue their growth within the tissues. These reproductive bodies doubtless fall upon the leaves of many other plants besides the vine, but although they may germinate in such cases, they are unable to penetrate the cuticle, or, succeeding in this, they do not find within these plants the food elements they require and quickly die. The mycelial threads of the Downy Mildew do not penetrate the cells composing the tissues of the vine, but grow between them in all directions, the more humid the atmosphere, the more moisture there is in the tissues, the more rapid is this growth. After a certain time branches of the

mycelium are sent out into the air, especially from the under sides of the leaves, and on these the spores are borne. Three of these branches covered with spores, are shown in fig. 1488. By their multitude these form more or less extended frost-like or downy patches visible to the naked eye. This stage in the development of the fungus is familiar to everyone, and has come to be familiarly termed the "Downy Mildew." We must not forget, however, that before this outward development takes place, the fungus may have been vegetating within the leaf-tissues for some time, and it should be borne in mind also, that the fungus may grow vigorously within these tissues without appearing on the surface at all. The conditions are not always favorable for the outside growth, and, besides, it appears impossible for the fungus to force an exit through the outer tissues of some of the vine organs.

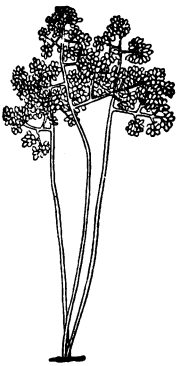

Fig. 1488.

The Downy Mildew may attack the vine at any time during the season of growth, from the time the leaves first appear until they are about ready to fall; but the attacks which are most injurious to the foliage usually occur in August or September. It is through the earlier attacks in June or July (in August at the North) that the berries may suffer directly, resulting in Brown-rot.

If infested when quite small, say about the size of peas or a little larger, the further growth of the berries is checked, and they often become covered as if by frost with the spore-bearing filaments mentioned above and

illustrated in figure 1488. These small berries remain plump and green for a time, but they finally dry up and turn black.

The peculiar characteristics of Brown-rot appear only in berries that are attacked when nearly full grown. Upon these the fungus rarely if ever appears on the outside, but the growth within goes on more or less rapidly, determined probably by the juiciness of the

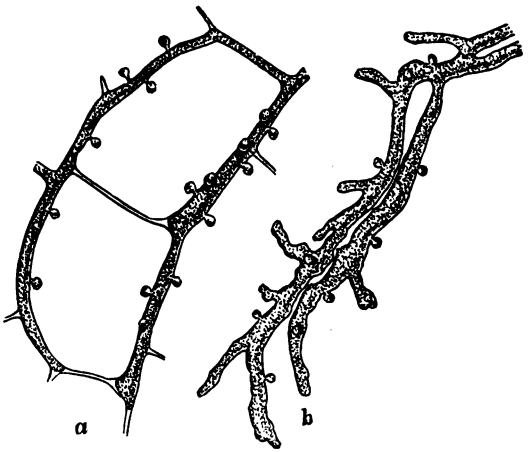

Fig. 1489. Mycelial threads of the Downy Mildew, seen in the tissue of the berry.

berry and external atmospheric conditions of moisture and temperature. The mycelium grows between the cells, sending into the latter short rounded branches, called suckers, through which the fungus imbibes its nourishment. In figure 1489 a portion of a few cells of a grape berry are shown very highly magnified, with the mycelium (the shaded portion) growing between them.

The suckers entering the cells are seen to be quite numerous. In consequence of this growth, the contents of the cells turn brown, their vitality is finally destroyed, and they become more or less shrunken. Externally, these changes appear to progress slowly. The berries attacked, however, are quickly distinguished from those which are healthy by having a grayish or less vivid color. Soon marked discolorations appear here and there over the surface, and at these points the skin becomes more or less depressed by the shrinking of the tissues beneath. As the disease progresses, the berries become more and more withered, and lifeless in appearance, and finally turn dark brown. They do not dry up and present the hard and prominent wrinkles of berries destroyed by Black-rot, nor do they present on their surfaces the small black pimples characteristic of that disease. In their earlier stages these two diseases are difficult to distinguish, but the appearance of black pimples or pustules on the surface of the berry in the case of Black-rot enables one to determine between the two at a glance.

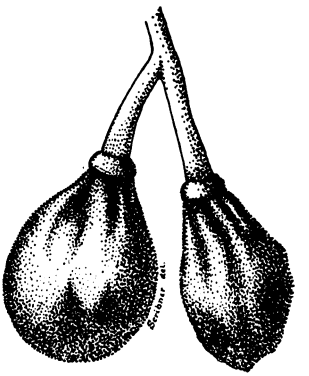

Fig. 252. Grape berries attacked by Brown-rot.

When the fungus does not come out on the surface, we can determine if the berries are suffering, from this or some other cause, only by a microscopical examination of their tissues. The microscope will quickly reveal the mycelium of the fungus if present, and there is no

mistaking the mycelium of the *Peronospora* for that of any other fungus which infests the vine.

We have spoken of the reproductive bodies or spores produced on branches of the mycelium that extend outside the vine. There is another kind of spore produced by the fungus on the mycelium within the tissues of the parts attacked. These are called egg-spores (oospores); they live through the winter season and serve to propagate the fungus the following spring. Several of these egg-spores, found in the tissues of a berry destroyed by Brown-rot, are shown, highly magnified (*b*), in Fig. 1490. They are nearly round and have very thick walls. In the same figure, and equally magnified, are shown some of the summer spores (*a*) which are borne on the external branches.

Fig. 1490.

Under Black-rot of Grapes we have referred to the very serious losses in the North caused by the *Peronospora* attacking the berries, producing Brown-rot. In the more Southern States it is the foliage which suffers most, the berries being rarely attacked.

TREATMENT.

It has been very thoroughly demonstrated that the Bordeaux mixture (containing 4-7 per cent. of sulphate of copper) or eau celeste (containing 1 per cent. of sulphate of copper) are efficient remedies, when properly prepared and applied, for Downy Mildew. In localities where there are frequent dews, sulphatine (a powder containing 10 per cent. of sulphate of copper) has also given excellent results. In ordinary seasons, three applications of these remedies should be made, about

one month apart, beginning soon after the first leaves are fully formed. The amount of material required per 1000 vines will depend somewhat upon the style of pruning and age of the vines, (i. e. the first application will require less than the second and third), and the spraying apparatus used. In general we may say for the first application 12 gallons, the second 18 gallons, the third 25 gallons. The amount of powder—35 lbs. per 1000 vines for the first application, 50 lbs. for the second and 70 lbs. for the third. In wet seasons the number of applications should be increased to five or six.

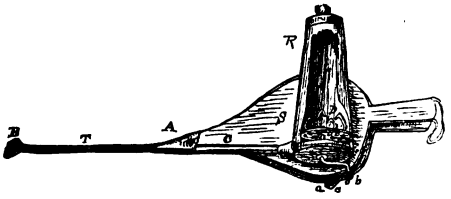

Fig. 1498.

One cannot hope to attain the best results unless provided with a good spraying apparatus or bellows. On page 19 is illustrated one of the most approved styles of portable pumps now in general use in France. With such an apparatus one man is able to treat five acres per day. An excellent form of bellows is shown in Fig. 1498. The weight of the powder comes near the hand, an important consideration. Inside the powder receptacle is an agitator, which works the powder through a sieve placed near the bottom. The blast from the bellows passes into the compartment below this sieve, forcing the powder through the nozzle. This form of bellows does not become clogged and the delivery is very uniform.

SUCCESSFUL TREATMENT OF BROWN-ROT OF GRAPES WITH EAU CELESTE.

On the 18th of August, we visited a small vineyard on Kelly's Island in Lake Erie, and were much surprised at the extent to which the grapes had been destroyed by Brown-rot which, as is well known, results from attacks of *Peronospora viticola*, the fungus familiarly known as Mildew or Downy Mildew. The foliage of the vines had not at that time become very much injured but the fruit had suffered severely and from 15 to 20 per cent. of the berries were already diseased. The extent of the ravages was almost comparable to those of Black-rot in the Middle Atlantic States. Of the latter disease I saw no indications on the fruit. Anthracnose, however, was quite common, sometimes taking nearly all the berries in a cluster. There were many cases where the berries were seen suffering from the attacks of both Brown-rot and Anthracnose.

We no longer need to feel alarmed at the presence of this disease (Brown-rot) for it may be prevented with certainty and comparative ease by applications of almost any of the now well-known sulphate of copper compounds. There is no longer any doubt as to the efficacy of these preparations in combating the *Peronospora*. The experiments made by Mr. Geo. M. High, of Middle Bass, in treating the Brown-rot with *eau celeste* the past season are interesting, particularly to the vineyardist on the Islands and adjacent parts of Ohio, where Brown-rot prevails rather than Brown-rot.

Mr. High used eau celeste, treating a number of varieties, chiefly Catawbas. The apparatus used was a Nixon barrel force pump and sprayer, with a No. 4

nozzle of the same maker. The first application was made June 7, about 10 days before bloom. One half the vineyard, the east side, embracing about 2000 vines, was again sprayed on June 18. The blossoms were just falling off at that time. To the same part the applications were repeated July 6, July 18 and August 7. This lot of vines showed hardly any signs of mildew or rot up to August 16. Some 2000 vines adjoining, which were left untreated, had lost, up to the same date, from ¼ to ⅓ of their berries by rot, and their foliage was much injured by the mildew.

The 2000 vines on the west side, treated with the east lot June 7, were treated again June 25, July 14 and August 7. This lot rotted slightly but not to an extent exceeding 2 per cent. of the crop.

The season throughout was warm and moist. At no time was the ground dry, and all the conditions were particularly favorable for the development of mildew and rot. The applications of eau celeste saved both fruit and foliage in an almost perfect condition. Mr. High says in so many words that he does not believe there is a vineyard of Catawbas on North Bass or Put-in-Bay Islands which has not lost by rot and mildew from ¼ to ⅓ or more of its crop, while on his eau celeste treated vines the loss will not amount to 1 per cent.

Cost of material per acre for each application was 30 cents.

2 lbs. sulphate of copper 1 qt. liquid ammonia 56 gallons of water.	Amount used per acre; vines planted 6x7 ft.

The barrel pump and sprayer cost $35—exclusive of

freight. No price given for labor; but with the apparatus used two men and a horse were required, the spray being applied just as fast as the horse could walk through the rows.

The next year we again visited Kelly's Island, also Middle Bass and Put-in-Bay, and found the crop in untreated vineyards very seriously injured by Brown-rot. A number of vineyardists, following Mr. High's example, had regularly sprayed their vines with eau celeste and upon these it required careful search to find a single rotted berry.

CHAPTER VI.

THE POWDERY MILDEW OF THE VINE.
(*Uncinula ampelopsidis*).

The Powdery Mildews are of special interest to the horticulturist, as they are widely distributed, numerous in species, and attack a great variety of plants. They are all surface-growers, i. e. they grow entirely upon the surface of the plants which they infest, and for this reason they are far more easily combated than those fungi which penetrate the tissues more or less deeply. There is the Powdery Mildew of the Cherry, of the Rose, of the Pea, of the Gooseberry, of the Maple, of the Oak, of the Catalpa, of the Lilac, of Wheat, of the Grape, all, and many others besides, may be found in almost any county in any State. Nearly all appear as a white, powdery or mealy substance upon the *upper* surface of the leaves. They are not confined to the foliage but may attack any of the growing or green parts. All the species are true parasites, attacking only living plants from which they obtain the nourishment required for their own support, the supporting plants being called, as we have already said, *host*-plants.

The grape vine is the host-plant of the fungus which forms the subject of this article and which is now very widely known as the Powdery Mildew of the vine. It has been often referred to, however, simply as "Mildew,"

but this expression leads to confusion, for there are two Mildews that infest the vine, the Downy (*Peronospora*) and the Powdery (*Uncinula*), and unless some special term is applied to each, it becomes uncertain which is meant. Powdery, is a descriptive term and has been well employed to distinguish such fungi as this *Uncinula*, for they impart to the surfaces upon which they grow, a marked powdery or mealy appearance. Much has been said and written about the *Uncinula ampelopsidis* under the name of Oidium or *Oidium Tuckeri*, and botanists have described it under the names of *Uncinula spiralis* and *Uncinula Americana*.

All these names refer to one and the same thing—the Powdery Mildew of the vine—a fungus native to the United States, and found throughout all our grape-growing regions even to the Pacific coast. In fact, it is more injurious in California, on vines of the Vinifera family, than it is in the Eastern States. Here it rarely occasions serious damage excepting in graperies. The European grapes which we grow under glass, are very apt, unless carefully watched, to suffer severely from attacks of this parasite. It has been reported to us as being very injurious to the same class of vines when grown out of doors, as they sometimes are in the Gulf States. Western New York and Northern Ohio is where we have seen this fungus most abundant in the open vineyard. However, the losses which it there occasions are very inconsiderable as compared with those caused by the Downy Mildew. Here and there on isolated vines, we have seen one to several leaves with their *upper* surfaces whitened by the presence of this parasite, and also an occasional cluster of grapes with its fruit

more or less damaged by it. The injury done may amount to a good deal if the clusters are attacked when in flower, for then fertilization is checked or prevented, and doubtless much of the disease known as *coulure* is the result of such an attack.

Unlike the Downy Mildew, Black-rot fungus, etc., the fungus of Powdery Mildew never penetrates the tissues of the host-plant but extends its growth on and over the surface of the part attacked, simply sending into the epidermal cells of the host little suckers through which it imbibes its nourishment. These suckers are shown in figure 1616, as small, irregular projections on the lower side of the mycelial filaments. The plant body of the parasite is, therefore, fully exposed to any direct applications which may be made to destroy it.

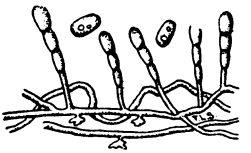

Fig. 1616.

The Powdery Mildew produces two very unlike sets of reproductive bodies—spores. During the early part of the season, the mycelial threads send up short, erect branches which bear the summer or oidium spores. These are shown, highly magnified, in figure 1616. The spores thus produced are very numerous, and as they are ready to germinate as soon as they have fallen from their supports, the spread of the fungus during summer is often very rapid. Later in the season, the second form of spores are produced, and as these are carefully protected in what may be termed little capsules, they serve to carry the fungus over from one season to the next, and therefore they are sometimes called winter spores.

These winter spores are formed in little sacs which are enveloped in a hard, globular covering from which radiate a number of delicate appendages which are curled at their tips. When mature the globular body (termed *perithecium*) is black and sufficiently large to be detected by the unaided eye. They are usually abundant by the middle of August, especially in the North, and appear on the mildewed surfaces as minute, black specks. One of these bodies with its appendages is shown in figure 1617. At the left we have the same with the radiating arms cut off and the spore-containing sacs within escaping through a rupture in its wall.

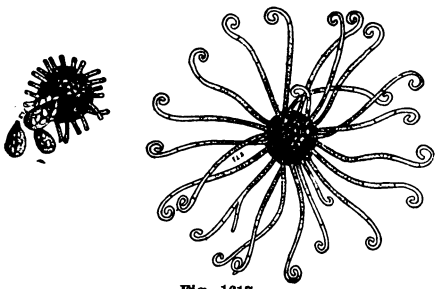

Fig. 1617.

TREATMENT.

Flowers of sulphur dusted on the vines (or, in hot climates, simply spread over the ground beneath them) serves effectually to destroy the Powdery Mildew. No other treatment is needed to protect the vines from this parasite. In regions where the fungus is most injurious it is the custom of vineyardists to make at least three applications; first, when the young shoots are about four inches long; second, when the vines are in bloom; and third, just before the berries begin to color.

In the Report of the U. S. Department of Agriculture for 1888, page 333, is given the experience of Mr. E. M.

Hudson of Mobile Co., Alabama, in treating the Powdery Mildew which attacked his European vines. Mr. H. says: "I commenced when the shoots were perhaps 6 to 8 inches long, with a solution of half an ounce (avoirdupois) of the liver of sulphur to one gallon of water. A second application was made when the grapes were beginning to color. The solution happened to be quite powerful enough and produced no injurious effects whatever on the tender leaves and shoots. This treatment was applied to two hundred vines (all marked) with absolute and unexceptional success, giving me a full crop of superb clusters of magnificent berries in every instance. About thirty-four vines, interspersed among those treated as above, and left wholly untreated, had their entire crop destroyed by the mildew.

* * * * * *

"In preparing the solution, half an ounce of the liver of sulphur was dissolved in one pint of hot water; as soon as dissolved, the cold water (1 gal. less 1 pint) was poured with the hot solution and the whole immediately strained through a thick Osnaburg cloth into a tin can and closely stopped. It was then ready for use. * * * On 250 vines 4 gallons of water with 2 oz. of liver of sulphur were used at each application. * * * The applications were made early in the morning with a Vermorel sprayer, the solution being freshly prepared."

CHAPTER VII.

GRAPE-LEAF BLIGHT.
(*Cladosporium viticolum.*)

A fungus quite unlike either the Downy or Powdery Mildews, or the fungus of Black-rot, attacks the foliage of the vine causing a disease which we have named Grape-leaf Blight. It is to be found on both wild and cultivated vines throughout the regions east of the Mississippi and extends southwestward into Texas. It is also found in Europe. We have seen it the past season on wild vines in Canada and we have never been in a vineyard, within the range specified, where we have not seen more or less of this Blight. Usually appearing quite early in the season, it first attacks the lowermost leaves, and increases in abundance as the season advances. In the eastern and northern Middle States its ravages are usually of small extent and the injury occasioned unimportant, but in the South, in North Carolina and especially in Tennessee, its effects are sometimes serious.

In a vineyard of Concords, Delawares, Catawbas and Red Wyomings, which we had under inspection the past summer, we noticed the Leaf-Blight on all the varieties, but most on the Catawbas and least on the Delawares. Early in July it had spread over some of the Catawba vines even to the highest and most exposed leaves, the

blight spots being numerous and unusually large. A small vineyard of Concords in this vicinity (Knoxville), which we visited about September 10, presented a remarkable instance of the severity of this disease. From our first glance at the vineyard we thought that the foliage had been injured or rather destroyed—for practically it was destroyed—by the Downy Mildew, and we were much surprised when upon closer inspection, even after careful search, we found no trace of the mildew in it; but the blight fungus was everywhere, much of the foliage had already fallen through the action of the parasite, and there was not a leaf remaining on the vines that did not show the marks of the disease. These were spotted and blotched in all degrees, some but slightly, others covered with numerous and rather small spots, while others still, and these were in the large majority, presented a blotched and blackened appearance as if burned with a hot iron. Such was the condition of the foliage that the possibility of the blight fungus to become, under some circumstances, a serious pest, at least in this latitude, could not be questioned. The fruit in the vineyard had been harvested at the time of our visit, so it is very likely that the crop was little if at all affected by the Blight. The vines, however, could not pass uninjured this early destruction of the foliage, a fact which doubtless will be made evident next year by an enfeebled growth and diminished crop.

The spots of the Leaf Blight are readily distinguished from those caused by Black-rot (Leaf-spot disease) by their more irregular outline, much darker color, and absence of the numerous, usually concentrically arranged, black points or pustules which characterize the

latter. In the violent form in which the disease occurs here, the spots are much larger, still more irregular in outline and very dark brown in color, appearing almost black. The leaf tissue within the spots is killed and becomes dry and brittle. Such large and irregular spots may be mistaken for the effects of mildew, but the entire absence of the white, frosty or downy external growth of this parasite serves to distinguish it. Besides, we can usually detect the Blight fungus with the naked eye by folding a diseased leaf over the finger and looking across one of the spots against the light or a white surface, In this way we see the spore-bearing filaments, or rather bundles of filaments, standing upright, as fine, hair-like projections scattered, more or less thickly, over the surface. One of these bundles, very highly magnified, for they are rarely 1-25 of an inch high, is shown in figure 1615, together with some of the detached spores, equally magnified. The body of the fungus, consisting of slender, dark-colored, tubular filaments with many cross walls or septa, lies buried within the tissue of the leaf in the discolored spots.

Fig. 1615.

The general shape of the dark, olive-brown spores is illustrated in the figure. These are produced in great abundance during damp weather, and as they germinate readily in condensed moisture, the disease often spreads with great rapidity. The mycelinm lives in the fallen leaves through the winter and is ready to produce a new crop of spores in the first warm days of spring.

No attention has been paid to the treatment of this disease, for it attacks only the foliage and has generally been regarded with indifference. We have seen, however, that in exceptional cases at least, it may do serious injury to the vines, and a knowledge of its appearance and habits becomes important. Certainly all the fallen leaves harboring the fungus, ought to be destroyed as one means of mitigating the ravages of this parasite. What effect the cupric solutions, employed in treating mildew and rot, may have upon it is yet to be determined. Our own observations in this direction are rather limited but lead us to infer that they are of no avail. We have seen the fungus in full development and well fruited on leaves thoroughly coated with the Bordeaux mixture.

CHAPTER VIII.

ROOT-ROT OF THE VINE.

Very little has been said or published in this country about the Vine Root-rot, a disease long known in Europe, where it has been carefully studied by German, French and Italian investigators. Our own observations have led us to the conclusion that it is by no means an uncommon disease here, at least in the southern districts. It was first discovered in a vineyard near St. Louis, Mo., by Professor Viala, in 1887, and in company with this learned viticulturist we found it in northeastern Texas and again in Napa Valley, California. During the past season we have seen here, in the vicinity of Knoxville, Tenn., a number of vines which were nearly or quite dead from this same disease.

The roots of vines may decay through accidental or mechanical injury or on account of some physiological disorder, but the disease we are considering is caused by the attacks of a fungus, or rather by the attack of fungi—for more than one of these plant pests may produce the disease—and, as a vine once infested is doomed to destruction, and as infection may spread through the ground from one vine to another, grape-growers ought to learn to recognize the malady that they may adopt measures to prevent it or check its progress.

The fungi which, in Europe, have been positively identified as causing Root-rot of the vine are *Agaricus melleus* and *Dematophora necatrix*. The conditions under which the disease appears and the characters presented by the affected vines observed in this country are identical with those occurring in Europe, and although we have not followed the fungi seen here through all their stages of development, we have little hesitation in pronouncing them the same as those above named. For the practical purposes of the vineyardists there is certainly no distinction to be made.

The first, *Agaricus melleus*, we have seen on vine roots in California, while all the affected vines observed here in the East appear to have been attacked by the second, *Dematophora necatrix*. The latter is generally conceded to be the more common cause of Vine Root-rot. These fungi are both parasitic and saprophytic in their habits, i. e. they may attack healthy roots and after these have been killed, live upon their decaying remains. They appear to have the power of living, for a time at least, upon whatever vegetable mold there may be in the soil, and from this spreading to the living roots of plants coming within their reach, for their attacks are not limited to the vine; they are known to have the power of infesting a number of our fruit and forest trees and even some of the field and garden vegetables, as the potato, beet, etc.

Vines diseased with Root-rot exhibit no characters above ground which might not appear from any other injury of the roots; the effect upon the vine as well as the manner in which the disease spreads in a vineyard is the same as in the case of the *Phylloxera* or root-louse.

The first effect is the production of an excessively abundant crop. Then the vines exhibit an enfeebled condition; the shoots pushed forth, usually numerous, remain slender and short; the leaves are small and usually more deeply cut than is normal, and within a year or two the vines die. In experiments made by Viala upon young vines in pots, these died six months after being infected with fungus (*Dematophora.*) The roots become spongy, of a dark-brown color in the interior, and finally decompose.

Root-rot appears most frequently in clayey or marly soils where there is standing water, and in those having an impermeable subsoil. It often appears in little depressions in a vineyard where water accumulates and remains for a considerable time, other and dryer parts of the same vineyard being entirely free from the disease. Excess of moisture in the soil is one of the chief conditions favoring Root-rot. In sandy or granitic soils overlying a porous subsoil, or which may be well drained in other ways, the disease rarely appears and never with any great severity. It is most likely to appear in vineyards planted on newly cleared forest lands, especially after oaks, as in the case observed by us in California.

The influence of temperature on the development of Root-rot is secondary to that of moisture; however, it progresses most rapidly when the temperature ranges between 70 and 80 degrees F.

The mature or fruiting state of *Agaricus melleus*, shown in figure 1485, is comparable to that of the common mushroom, and like that fungus it is edible. We have seen this mature form in the vicinity of Wash-

ington, D. C., and, in most luxuriant development, in oak forests near Dallas, Texas. The color of the cap, which may be from 3 to 6 inches in diameter, is a clear

Fig. 1485. Agaricus melleus.

brownish-yellow, becoming darker with age. Over its surface are scattered small, brownish, hairy scales, and on the under side are numerous thin radiating plates (gills) which are white, spotted with dull red. On these the spores are borne.

The mycelium of this fungus forms much branched, root-like cords, that are very dark brown or nearly black on the outside and white within. These growing through the soil meet roots of the vine, penetrate the bark of the latter, between which and the wood they continue their growth, remaining as slightly flattened cords distending and even rupturing the bark over them, or spreading out into thin felt-like plaques, often of considerable extent, with elegant fringe-like borders. These flat expansions are whitish in color, and show a marked phosphorescence in the dark. We have seen the rhizomorphs following the irregularities of the vine roots, embedding themselves under the bark and reappearing upon the surface again farther on, as illustrated in figure 1622. The finer mycelial filaments penetrate into all parts of the roots, causing their final decomposition.

Fig. 1622. A piece of vine-root affected with "Pourridie," on the surface of which are the "cords" of *Agaricus melleus* (after Millardet.)

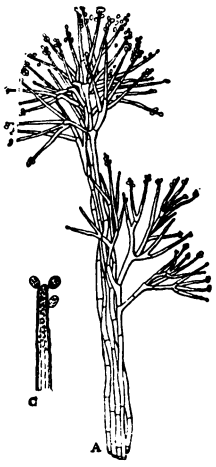

Fig. 1623. Spore-bearing fruiting stalks of *Dematophora necatrix* (after Hartig.)

The other fungus to which we have referred—*Dematophora necatrix*—lives upon a great num-

ber of fruit trees and other plants which are destroyed by its attacks. The fruiting season of this fungus is very unlike that of the *Agaricus*. The spores are borne upon the terminal branches of little bundles of filaments (see figure 1623) that are scarcely more than one-fiftieth of an inch high. These under favorable conditions are produced in great abundance, and the number of spores they yield is enormous. Roots of the vine attacked by this parasite present, between the bark and the wood, felt-like plaques composed of matted mycelial threads. This mycelium penetrates to the pith through the wood-rays (medullary rays), and like the *Agaricus*, finally causes the decomposition of the roots. Like the *Agaricus* also, the mycelium of the *Dematophora* forms root-like cords which grow through the soil, but these are lighter in color and much more delicate, and the mycelial threads composing them exhibit different characters when viewed under the microscope. A few of these filaments are shown in figure 1624. The brown exterior threads are decidedly swollen and somewhat pear-shaped where the septa or cross walls occur,—much more so than is indicated in the figure. In figure 1625, we have

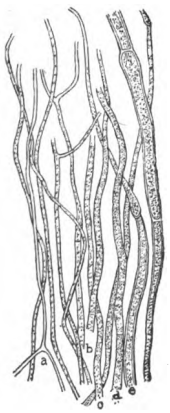

Fig. 1624. Colorless mycelial filaments of *Dematophora necatrix* (after Viala).

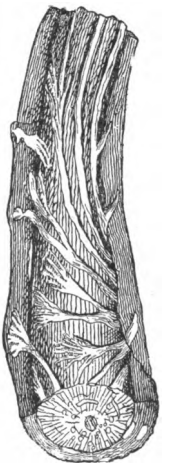

Fig. 1625.

illustrated a fragment of root killed by the *Dematophora*, the bark being removed from the side in view, showing the extension of the mycelium on the wood, and points where it has entered the bark.

TREATMENT.

It is evident from the fact that the fungi causing Root-rot bury themselves within the tissues of the roots, and this to a considerable extent before the presence of the disease may be suspected, that any direct means of combating the evil are out of the question. That which would destroy the fungus would without doubt be equally destructive to the vine. But we may prevent the disease, or at least check its spreading. As moisture is the primary favoring element to the development of the disease, this should be removed as far as possible by thorough draining. The depressions in the vineyard where water is liable to accumulate should receive most careful attention in this respect, for it is at these points that Root-rot is most likely to appear. When an affected vine is discovered it ought to be removed from the vineyard at once and *all* its roots carefully dug up and burned. The vines adjacent ought to be treated in like manner, for as the fungi spread through the soil, the roots of these will afford new feeding ground for them, if they (the roots) are not already found to be infested. The surface then should be cleaned of all vegetation and so maintained for at least two years. As a precaution against the extension of the mycelium in the soil, a ditch two feet deep should be dug around the infected area. It is hardly necessary to add that vines should not be planted where trees of

any kind affected with Root-rot have been removed. Before use such land should be treated as just indicated for the infected area in a vineyard. Chips or waste from a wood-yard used as a mulch about vines, will serve to invite the disease if they do not directly infect the soil with Root-rot.

CHAPTER IX.

ANTHRACNOSE AND BIRD'S-EYE ROT.
(*Sphaceloma ampelinum.*)

The name Bird's-eye Rot has, in some localities, been applied to that form of grape rot caused by *Sphaceloma ampelinum*, the fungus of Anthracnose. The disease produced is a species of dry rot, and it often happens that the above name is particularly descriptive of its appearance on the fruit, so much so, in fact, as to render its general adoption very proper.

The Spaceloma attacks all the green parts of the vine at any period during the growing season, being more especially active in early summer while the growing parts are yet tender. The effect on the canes and shoots is more or less severe according to the season, the growth of the fungus being favored by continued damp weather, and some varieties of vines always suffer more than others. The flowers are sometimes attacked before they are fairly formed, and from this time until the fruit begins to ripen, the clusters may become infested. M. Foex (Cours Complet de Viticulture, p. 448) states that the vines especially subject to this disease are the Carignane, Terret, Œllade, Morrestel, and Cot, of Vitis vinifera, and Jaquez of Vitis Æstivalis. The cultivation of the last named variety has been entirely abandoned in some sections because of its great susceptibil-

ity to Anthracnose. The Elvira is a grape which is also very subject to this disease, sometimes the entire crop being destroyed.

It does not come within the limits of this work to describe the action and appearance of the fungus on the shoots and foliage; we must confine ourselves to the action of the parasite upon the berries.

Bird's-eye Rot first appears as a dark reddish-brown or nearly black speck on any part of the berry. These specks gradually increase in size to ⅛ or ¼ of an inch, usually preserving a somewhat rounded outline.

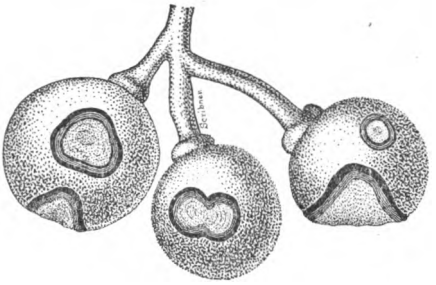

Fig. 251. Bird's-eye Rot of Grapes.

Their centers soon take on a grayish hue, the dark brown color being confined to a narrow line bordering the spots. Sometimes there appears within the dark colored border a band or ring of bright red or vermilion —when the spots suggest the name "Bird's-eye Rot." During the progress of the disease there is no general withering, or softening, or browning of the berries, but the tissues beneath the spots gradually lose their turgescence; the cells collapse and become dry and hard. In advanced stages, the berries, reduced to ¼ their original size, usually exhibit the distinct outline of the original spots. Berries when only slightly affected may simply become misshapen, the parts where the spots are located having ceased to grow, or they may out-grow

the effects of the disease, when the only evidence of the spots left is a gray or brown scurf covering the surface. If attacked upon one side when quite small, the continued growth of the healthy portion will often cause the diseased side to crack open, laying bare the seeds. The latter are sometimes pushed completely out by this unequal growth.

Unlike the Downy Mildew or the fungus of the Black-rot, the growth of the Sphaceloma is limited to the outer layers of cells, developing between the cuticle and the epidermis or just underneath the latter. There are no mycelial threads penetrating deeply within the tissues and, in consequence, it is more easily accessible to remedies than the species possessing this latter habit.

The spores, germinating upon the surface of the berry, send a germ-tube through the cuticle or epidermis, beneath which the fungus vegetates for a time, developing into a kind of parenchymatous or cellular growth, which at length breaks through the epidermis. From the now exposed portion of the fungus there arise numerous short branches, called basidia, on which the spores or reproductive bodies are borne. The fungus, as it now appears, is shown in figure 1511; *a*, *a*, are the dried and flattened cells of the tissue of the berry; *b*, *b*, is the cuticle; *d*, *d*, represents the plant body of the fungus; *e*, *e*, are the basidia, on which are borne the spores. A com-

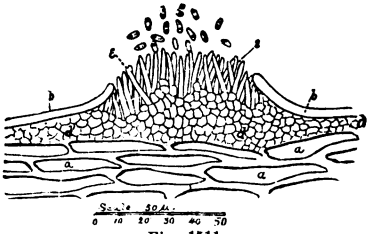

Fig. 1511.

parison of this figure with the illustrations of *Peronospora viticola* or *Laestadia Bidwellii* will show how very unlike these fungi are in their growth and other characters.

TREATMENT.

The treatment of Anthracnose is to wash the vines after pruning and before the buds have commenced to expand, with a strong (50 per cent.) solution of sulphate of iron, or a 10 per cent. solution of sulphate of copper. This treatment repeated for several successive seasons will usually free the vineyard from the disease. If the malady appears during the growing season, applications of sulphur, or powdered lime and sulphur mixed in equal parts, and applied when the dew is on, have afforded relief. It has been noted in some instances, even where the disease was progressing rapidly, that applications of the Bordeaux mixture served to check it completely. The treatments made with the preparations of sulphate of copper for combating the Mildew or Black-rot will doubtless afford ample protection against Bird's-eye rot.

In "Le Progres Agricole" for October 26, 1890, we find the following preparation recommended for the treatment of Anthracnose:

Water	3 gals.
Sulphate of Iron	7 lbs.
Sulphate of Copper	2 lbs.
Sulphuric acid	1 gill.

This is to be applied to the vines two or three weeks before vegetation starts in the spring.

A powder which is highly recommended as a remedy for Anthracnose, is prepared by mixing in equal parts Portland cement and sublimated sulphur, to which is

added one to five per cent. of finely powdered sulphate of copper. This compound should be applied just after rains or when the dew is on, in order that it may adhere well. Three applications are recommended to be made during the growing season.

CHAPTER X.

DOTTED OR SPECKLED ANTHRACNOSE OF THE VINE.

There is a form of Anthracnose which the French name "*Anthracnose ponctuee*," in distinction from "*Anthracnose maculee*," the disease which we have simply termed Anthracnose. Dotted Anthracnose is common throughout Europe, and in this country throughout the vine-growing regions east of the Rocky Mountains. It attacks all varieties of vines, both wild and cultivated, but more particularly *Vitis riparia* and *Vitis rupestris*, and the varieties originating from these species. In nearly all vineyards which we have visited in the Middle and Eastern States we have noted the presence of this disease, but have been led to consider it of little importance. It appears, however, that under some circumstances it may occasion considerable injury to the vines, and vineyardists should learn to recognize and distinguish it from other vine diseases.

Last December we received from Col. Pearson, of Vineland, N. J., some vine shoots diseased with the form of Anthracnose we are here discussing. Respecting the disease, Col. Pearson says in a letter accompanying the specimens: "It infests principally the Iron-clads, though I observed some of it on other vines. It is spreading from vine to vine and from row to row.

Where it prevails worst the most of the top hamper of the vine is killed. I think it is somewhat allied to Anthracnose, as where this has been worst it is worst."

Comparing these shoots with specimens affected with "*Anthracnose ponctuee*" received from France (sent us by Prof. Viala), it was at once apparent that they were affected by the same malady. Additional specimens from Col. Pearson serve only to confirm the identity of the disease. Very recently we have had similar specimens, though less badly diseased, from a vineyard near Knoxville, the variety affected in this case being the Concord.

Fig. 344.

External characters of the disease.—Our figure (Fig. 344), drawn from a specimen received from Prof. Viala, gives a fair idea of the appearance of an affected shoot, although the dots are frequently much more numerous, as was the case with many samples from Vineland. Any part of the annual growth is subject to the disease—the green shoots, leaves, flower-clusters and fruit. It first appears as dark, shining, purplish-brown and slightly raised spots, hardly so large as the head of a common pin. These finally become black, and on the ripened wood are usually depressed in the centre, which results from the breaking of the cuticle. They do not increase much in size, but where they are very numerous they often run together or coalesce, forming very dark blotches of greater or less extent. The surface of these blotches is usually smooth and shining, and they occur most frequently on the side of the shoot most exposed to the light.

When the vines are severely attacked during the growing season, the growth of the primary shoots is checked, causing the production of a great number of lateral or secondary shoots, and there is generally a weakening of the foliage indicated by its paler and often yellowish hue. The leaves themselves are rarely attacked directly; when they are attacked, however, the disease appears on the nerves, never on the soft tissues between the nerves. When the disease attacks the young flower-clusters, *coulure*, or blighting of the flower buds, frequently results, and it is in such cases that this form of Anthracnose becomes most serious.

Microscopical characters. — We have only examined microscopically diseased, ripened shoots, like that shown in figure 344. Making an exceedingly thin section through the points of disease and examining the section under the compound microscope, we find a dense fungus growth of dark-colored mycelium, which sometimes slightly protrudes through the broken cuticle at the apex of the dots. Mycelium of the same character is often seen extending for some little distance around the dots, between the cuticle and the epidermis. The fungus is for the most part confined to the outermost layers of the bark, only very rarely is it seen in the inner or deeper layers. In figure 345 is shown a small section through one of the dots, the dark, heavy lines indicating the appearance and extent of growth of the fungus just

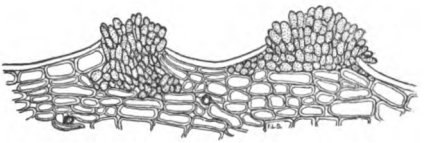

Fig. 345.

as we saw it. The fungus was not in fruit and we had no means of identifying it, but it certainly appears to us to be wholly distinct from the fungus which causes the better known form of Anthracnose. Prof. Viala believes, and thinks he has determined the matter conclusively by actual experiment, that *Anthracnose maculee* and *Anthracnose ponctuee*, are caused by the same parasite in different stages of its development, and this may be the case; very little is known of the life history of these fungi. Severe cases of Dotted Anthracnose sometimes result in the destruction of the bark and production of deep scars in the young wood, as often happens with ordinary Anthracnose. The effect of the latter on the fruit—causing Bird's-eye Rot—is always far more serious than that of the former. Both attack the same varieties of vines, but Dotted Anthracnose appears to require much less moisture for its development. The treatment for both is the same (see page 75).

CHAPTER XI.

BLACK-ROT OF THE APPLE.
Macrophoma malorum.

We have frequently observed a rotting of apples, the peculiar character of which leads us to designate it as the Black-rot of this fruit. It is not a new disease, for the fungus causing it has been known to mycologists for many years. We had our attention called to it this season by its appearance on the fruit of an early variety growing in our yard, many of the apples beginning to rot while yet hanging on the tree. Brown, decayed spots, often of considerable extent, appeared on the sides of the apples, generally starting near the stem, sometimes from the flower end, and spreading gradually over the surface. After a time, usually brief, the central portion of the brown spots became darker in color and finally quite black. In this blackened area there then appeared numerous, little, elevated points or pustules which in their formation ruptured

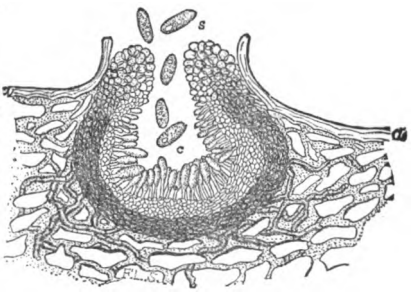

FIG. 1606.

the skin. They are often seen disposed in well defined concentric circles or zones over the decayed area. These little pustules call to mind those which appear on the grape when that fruit is affected with Black-rot; the color and the more or less depressed surrounding surface increase the resemblance.

Cutting open an apple through the decayed part, the tissue for a considerable depth is found to be rather dry and, while the mass is for the most part of a dull brown, there are scattered through it streaks or blotches that are nearly or quite black, this is especially marked in the tissues immediately underlying the pustules. The external characters of this form of rot are not unlike those presented by "Bitter-rot of Apples" described on page 348 of the Report of the U. S. Department of Agriculture for 1887; the fruit is affected much in the same way and, although differences in the appearance of the pustules may be detected by an expert, only a microscopical examination of the fungus will serve to clearly reveal the distinguishing features. Figure 1606 illustrates the microscopical appearance of a section cut vertically through one of the pustules that occur on the apple; showing the fungus in fruit, highly magnified, together with a small portion of the surrounding tissues. The pustule is formed by a black and thick-walled body which has pushed its way through the skin of the apple and in its interior are produced the spores of the fungus. These spores are supported on short stalks which spring from all parts of the interior of the cavity; they are filled with a granular contents which is at first colorless, but becomes a dark olivaceous green at

maturity. The ripe spores break away from their supports and escape through the opening at the top indicated in the figure. The spores are oblong in shape, broadly rounded at the ends and comparatively large, being 30 micromillimetres, or 1-1181 inches, in their longest diameter.

Surrounding each of the fruiting bodies of the fungus and abundantly spreading everywhere in the diseased tissue of the affected apple is the mycelium of the fungus, nearly colorless and thin-walled in the tissue that is simply brown, but very dark or almost black and thick-walled in the parts immediately surrounding the pustules and in the black streaks and blotches conspicuous in the decayed parts. It is the growth of this mycelium in the tissues of the apples which induces the changes termed rotting.

Black-rot of apples is common to both sides of the Atlantic, but we have no data upon which to base an estimate or even to form much of an idea of the extent of the losses occasioned by it; nor can we at this time propose any method of treatment which would be likely to be effective and at the same time practical.

CHAPTER XII.

APPLE RUST AND CEDAR APPLES.
(*Gymnosporanguim macropus*).

The group of fungi which contains the well known Wheat Rust includes a number of species which attack our pomaceous fruits, the most common being the Apple Rust (*Rœstelia pirata*). A portion of the life of this fungus is spent upon the Red Cedar, and wherever the Red Cedar grows there we may expect to find the Apple Rust. Most orchardists probably have noticed this fungus, or rather the effects caused by it, upon their fruit trees, but doubtless they have attributed what they have seen to insects. Insects are often blamed for injuries which are really caused by parasitic fungi. The singular growths, called "cedar apples," which result from the action of the fungus upon the Red Cedar, are by many considered a natural product of that tree.

The life history of this parasite has been carefully investigated by our mycologists and the various stages of its development made known. This development is most interesting, and as the fungus often occasions considerable injury by its attacks upon the apple, it will be especially so to the fruit grower.

The attacks of the fungus on the apple tree are first indicated during the latter part of May or early in June, by more or less numerous bright orange-yellow spots

which appear on the leaves. At these points of discoloration the leaf tissues are somewhat thickened. If, after a few days, we examine the spots closely we will discover very minute, nearly black points on the upper surface. These are the *spermogonia*, which if viewed under the microscope are seen to be hollow bodies that are lined with slender filaments bearing at their ends very minute spores that have been termed *spermatra*. The exact office or function of these spermatra in this case is not known. If, somewhat later in the season, we again examine the spots we will see, this time upon the under side, a number of little cups, each with a lacerated or fringed border. A cluster of these little cups is illustrated in figure 280. Within them will be found a fine, brownish, powdery substance, the spores of the *Rœstelia*, each particle, too minute to be seen with the naked eye, being a spore. The spores of this stage are called *æcidio spores*. A couple of them are shown, very much magnified, at *a* in figure 279; and at *b* in the same figure the manner of their germination is illustrated. This germination is easily induced, but as soon as the contents of the spore is exhausted, all further development ceases, unless the

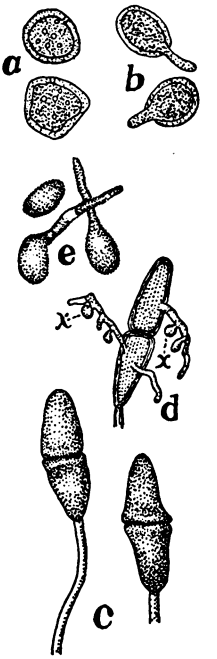

Fig. 279. *a*, Æcidio spores, seen in optical section. *b*, Germinating æcidio spores. *c*, Spores of the Gymnosporanguim or Cedar Apple. *d*, Germinating spore of same with sporidia at *x*, *x*. *e*, Germinating sporidia.

spores happen to be resting on the leaves of the Red Cedar, in which case the germ tubes penetrate to the tissues within the leaves, where the food necessary for their continued growth is found. They will not grow on the leaves of the apple, where they were produced, but germinating on the Red Cedar, they develop an abundant mycelial growth in the leaf tissues. The action of the mycelium upon the cells composing this tissue is to cause them to enlarge and multiply quite rapidly in an abnormal manner, resulting in the production of a hard, rounded, usually somewhat kidney-shaped body—the "Cedar Apple"—varying from a half inch to an inch and a half in diameter. These attain their full size in the early spring months and at that season the Cedars are often seen bearing quite a crop of these peculiar "apples." In this locality we have counted several hundred upon a single tree.

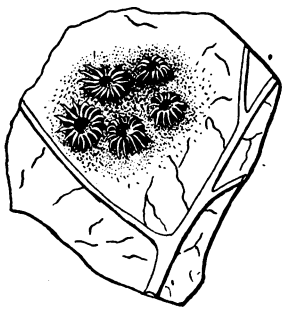

Fig. 280. Fragment of apple leaf showing the under side with the cluster-cups.

During the warm rains of April and early May, the fungus within the "Cedar Apples" comes to maturity and pushes forth a number of yellow, horn-shaped processes which, if the weather is wet, swell up and become soft and jelly-like. These out-growths are often an inch or two in length, and from their number and bright color, the "Cedar Apple" becomes a conspicuous object.

Figure 278 is designed to show a "Cedar Apple" with its horn-shaped but jelly-like appendages. These last

consist of a mass of swollen mycelial tubes, which have grown out from the body of the "apple" and which bear upon their free extremities two-celled spores like those at *c* in figure 279. These spores germinate very soon, even while still adhering to the jelly-like mass supporting them, but in manner quite different from that of the æcidio spores described above. They push forth a slender tube (sometimes several of them) along which are produced a number of very minute simple spores called *sporidia*. These sporidia are really the seeds of the Cedar Apple fungus, for it is by them that the parasite is propagated. They will germinate and grow, however, only upon the leaves (or fruit)

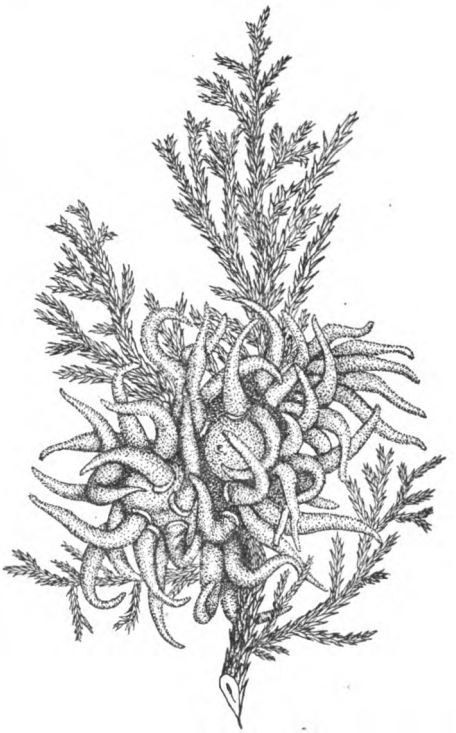

Fig. 278. Cedar Apple (*Gymnosporanguim macropus*).

of the apple tree and their product is the Apple Rust. The fungus, therefore, presents in its complete development two very distinct stages:—one on the apple, the *Ræstalia pirata* or Apple Rust, and the other on the Red Cedar and familiarly known as "Cedar Apple," named by the mycologist, *Gymnosporanguim macropus*. The spores from the *Ræstalia* stage, produced in midsummer, pass to the Cedar tree, which they infect, the result being the "Cedar Apple," whose spores mature in April or May and in turn pass to the Apple tree, causing the foliage of the latter to "rust." The young apples are attacked as well as the leaves; the fungus in them produces a swelling so that the fruit is misshapen and upon the swollen part both the spermogonia and the little spore-filled cups, described above, are formed. The "Cedar Apples" die as soon as their spore formation is completed, but in the apple tree the mycelium of the fungus sometimes endures from year to year in the young shoots and buds. This accounts for the frequent appearance of the rust on the earliest formed leaves even before the development of the new crop of spores on the "Cedar Apples."

The fruit, when attacked by the Rust, is rendered worthless, and the ripening of the fruit is occasionally prevented on account of the early destruction of foliage by the fungus. We have seen trees practically defoliated by the first of August from this cause.

PREVENTION OF THE DISEASE.

The Rust fungi are the most difficult to combat; their habit of passing certain periods of their lives on different host plants and of occasionally becoming

perennial in the plants they attack will account for this. As to the Apple Rust, it may be said that in localities where the Red Cedar is a rare tree or of no value it may be possible to free the orchards from the disease by destroying all the Cedars. To pursue such a course in this region or to attempt gathering the "Cedar Apples" before they produce their crop of spores, would be out of the question. We must seek other means of prevention, and the one which to us seems most practical is that of selecting resistant varieties. This power of resistance varies in the same variety in different localities. If the orchardist finds that certain varieties are being injured by the Rust, let him discard these. We once visited an orchard which was surrounded on two sides by Red Cedars which in the spring bore many "Cedar Apples;" there were several varieties of apples in the orchard, but the Rust had attacked only one of these. All the trees of this variety were affected in both foliage and fruit. So badly were these trees infected that we doubt if anything short of their complete destruction would destroy the fungus. The course we would recommend is as follows:

1. Remove from near the orchard all Red Cedars.

2. Remove badly infected trees and in their places plant known resistant varieties.

3. In localities where the Rust occurs spray all young trees and those which have not become too seriously diseased, with the Bordeaux mixture, making the first applications as soon as the first leaves are fully formed. There is no danger of infection after the "Cedar Apples" have dried up, nor before they have pushed forth their yellow, gelatinous appendages.

CHAPTER XIII.

APPLE-SCAB.
(*Fusicladium dendriticum*).

Of the two hundred or more fungi which mycologists have found on the apple tree or its fruit, the fungus which causes the "blight" of the leaves or the "scab" on the apple is the best known and by far the most injurious, at least to the crop. Wherever apples are grown for the market, we hear of their being more or less damaged by the "scab," or "black-spot," as some call it. From Maine to California it is well known and its ravages are severely felt by many orchardists throughout the breadth of our country. It is in the cooler regions that the disease is most severe; it is less prevalent in the warmer Southern States. But it is in the northern sections that the bulk of our apple crop is produced, and the climate most favorable to the crop is also most congenial to the fungus. Large orchardists have assured us that their individual losses on account of the "scab" sometimes amounted to a thousand dollars or more. The affected apples do not attain their normal size; nearly all must be classed as "seconds" or rated with those of value only for cider making.

In some States the loss from Apple-scab is said to amount to one-half the crop; the general annual loss from the disease is placed at from one-fourth to one-

sixth of the crop. Several years ago the Secretary of the Illinois Horticultural Society estimated that the loss in his State would amount to $400,000. The importance of gaining a practical knowledge of the habits of a fungus which so seriously affects one of our staple crops and of learning how to prevent its attacks is plainly evident. There are very many whom we know feel a vital interest in this subject and will be very glad to learn that an efficient remedy has been found for the disease.

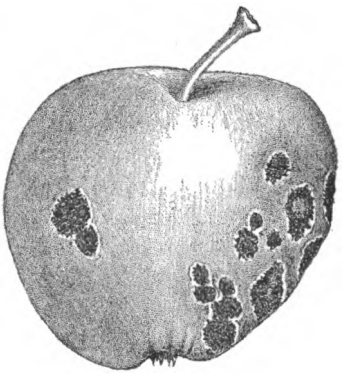

Fig. 273. Apple-scab.

It seems almost superfluous to describe here the external characters of Apple-scab. Every orchardist and dealer in apples is familiar with the appearance of the disease. Our illustration (figure 273), showing an affected fruit, will at once call the disease to mind. The fact that the same fungus also attacks the leaves and young shoots is not so generally well known. On the leaves the first manifestations of the presence of the parasite are the appearance, here and there over the surface, of smoky, olive-green spots, rounded in outline. The older spots range from one-eighth to one-half an inch in diameter, or they may appear as large, irregular blotches by the running together of several of the spots first formed. They are for the most part confined to the upper side of the leaf which often becomes much distorted through the un-

equal development of the two surfaces. The color of the older spots is nearly black and their surface somewhat velvety. The growth of the young shoots is often seriously checked through the direct action of the fungus upon them, and when the foliage of a tree is much affected its nutrition must be seriously impaired. The tree is rendered less able to withstand the severe cold of the winter season and is rendered more likely to injury from early or late frosts.

Cool weather, especially if accompanied with an excess of moisture, favors the development of the fungus, and it is during such periods that it vegetates and spreads most radidly. Figure 274 is an enlarged drawing of a section made through the edge of a "scab" spot from an apple which had been kept for several days in a moist atmosphere, and exhibits a luxuriant growth of the Apple-scab fungus. At *ep* is the cuticle of the apple, its broken edge turned back by the outward growth of the parasite; *f* illustrates the body of the fungus as seen in section under a strong microscope; *c*, epidermal cells. The growth of the fungus does not extend into the deeper tissues but is limited to the region between the cuticle and epidermis proper. Sometimes the cells composing the latter are

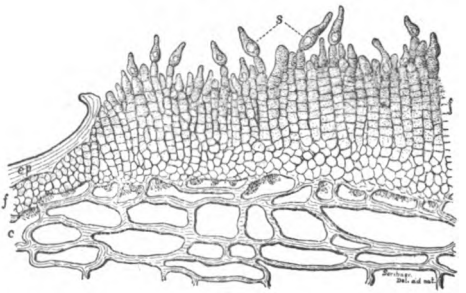

Fig. 274. Fungus of Apple-scab.

turned brown or even destroyed by the parasite and sometimes a few of the underlying pulp-cells of the fruit have their contents discolored, but the fungus itself never penetrates these. After the fungus has grown for a longer or shorter time beneath the cuticle it breaks through this covering and becomes exposed to the air. It is then ready to fruit or produce spores, which amounts to the same thing. The spores are borne on short upright stalks, the free ends of which are often much longer than are those in our illustration (figure 274), where the still attached spores are shown at *s*. They are oval or pear-shaped and dark olive-brown in color like the filaments which support them. They are produced in great numbers throughout the season of growth and on stored fruit, and are ready to germinate as soon as mature. We have seen them germinating while still attached to their supporting stalks. They will germinate in an atmosphere saturated with moisture and at a comparatively low temperature. A germinating spore is shown in figure 275. The germ-tube from a spore resting upon the surface of an apple penetrates the cuticle, between which and the epidermis further growth is continued, resulting finally in the rupture of the cuticle and the production of a new crop of spores.

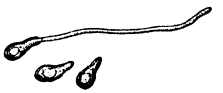

Fig. 275. Spores of fungus of Apple-scab. One germinating.

The development of the Apple-scab fungus is therefore very simple. No other stage than that here described and figured is known. The fungus lives through the winter in the fallen leaves, certainly in the harvested fruit and very likely also in the young shoots or autumn-

formed buds. From the latter it doubtless spreads to the new growths of the following season and thus the pest is perpetuated from year to year.

TREATMENT.

It is well known that some varieties of apples are more liable to "scab" than others, and in selecting varieties for culture the fruit-grower will take this fact into consideration. This means of avoiding the disease cannot always be depended on, for, as is also pretty well known, a given variety may be quite "resistant" in one section of the country, while in some other region it may prove most "susceptible."

Direct treatment by the use of fungicides is the only method by which we may hope to overcome the "scab." In the report of the U. S. Department of Agriculture for 1887, we recommended a course of treatment which has since proved most satisfactory so far as it has been carried out. The course laid down was as follows:

"(1) In early spring before the buds have commenced to expand, spray the trees thoroughly with a solution of sulphate of iron, using 4 pounds of the iron sulphate to 4 gallons of water.

"(2) As soon as the fruit has set, apply the Bordeaux mixture or one of the modified preparations of eau celeste [including the ammoniacal solution of carbonate of copper].

"(3) If the weather should be such as to favor the development of the 'scab' fungus, a third application should be made two or three weeks after the second, using the same materials.

"In storing the fruit for winter, special care should

be taken to separate all the apples showing any signs of the 'scab' from those which are smooth and healthy, and they all should be kept in rooms or cellars free from moisture."

The success attained last year by the use of the "modified" eau celeste and the ammoniacal solution of carbonate of copper proves the value of the above recommended course of treatment. We believe this demonstration would have been more complete and striking if the first item in the course had been carried out, that is, the washing or spraying of the trees with a strong solution of sulphate of iron before the expansion of the buds in early spring. We would now use sulphate of copper instead of sulphate of iron for this early treatment, one pound of sulphate of copper to ten gallons of water. For the treatments during the growing season, of which there should be at least three (one just before blossoming, one when the fruit is set and one when the fruit is half-growing), we would use either the ammoniacal solution of carbonate of copper or eau celeste containing carbonate of soda, giving preference to the former.

Formula for the ammoniacal solution of carbonate of copper:

Carbonate of copper (precipitated).....3 oz.
Aqua ammonia.....1 qt.
Water.....30 gal.

Dissolve the copper carbonate in the ammonia, then add the solution to the given amount of water.

Formula for the modified eau celeste:

Sulphate of copper..... .....1 lb.
Carbonate of soda .....2 lbs.
Aqua ammonia.....1½ pts.
Water .....30 gal.

Dissolve the copper sulphate and soda carbonate in separate vessels and then mix the two, add the ammonia, then add the solution thus formed to the amount of water named.

According to Prof. Goff, one and one-half gallons of the diluted solution is a quantity sufficient to spray thoroughly a tree of medium size.

1. Fruit from unsprayed trees.

1st. quality.	2nd. quality.	3rd. quality.

2. Fruit from trees sprayed with the carbonate of copper solution.

1st. quality.	2nd. quality.	3rd. quality.

Diagram showing the proportion of the fruit in each of the three qualities from trees treated with the carbonate of copper solution and from a like number of trees of the same kind untreated. Results obtained by Prof. E. S. Goff at the Wisconsin Agricultural Experiment Station, 1889.

CHAPTER XIV.

PEAR-SCAB.

A form of the same fungus which causes Apple-scab attacks the pear and is equally injurious to this fruit. Mr. W. T. Mann, of Barkers, N. Y., sends us specimens of pears that are badly diseased by this scab, and he writes that both apples and pears are so seriously affected in his locality this season that the crop will be almost a total failure.

The weather conditions during May and early June —rain nearly every other day and repeated late frosts —especially favored the development of the disease. In order to show how destructive a pest this Apple-scab fungus may become, we take the liberty of quoting from Mr. Mann's letter; "The Duchess is the only variety of apple that I have that will give even a partial crop. The trees of that variety are moderately full of fair fruit and the foliage looks fairly well. All other varieties in my orchards are a total failure and the little fruit now upon the trees are similar in appearance to the samples sent [very badly affected with scab]. The foliage of all trees that blossomed looks very badly and the older leaves are now dropping from the trees. The growth of the last two or three weeks [prior to June 30] looks bright and healthy. Of the pears the only variety that I have which will produce even a partial crop is the

Bartlett, and the fruit of this variety is all more or less blotched with the scab. Clapp's Favorite set a partial crop, but the fruit is so badly covered with the scab as to be worthless. All the other varieties have failed completely. The foliage of the pear trees looks fully as bad as that of the apple. * * * It should be stated, perhaps, that I noticed particularly that the embryo fruits of the Beurre D'Anjou pears were black and had the appearance of being covered with the scab, while the blossoms were still bright upon the trees and the bees were at work upon them. * * * A general opinion among fruit-growers here is that the electric storm of June 5, which was one of the heaviest thunder showers ever known in this locality, caused the destruction of the crops. The fact that my pear and main apple crops were ruined before that storm seems to me conclusive that that theory is not sound, still I would be glad to learn your opinion in regard to the probabilities of such a cause.

Fig. 295. A young pear affected by the Scab.

"The fruit interests of Niagara County are very large, and any information that you can furnish in regard to the cause of our losses and especially of practical remedies for the cause of these evil conditions will be of vast importance to our fruit-growers and place them under lasting obligations to you."

As stated above, the fungus that causes Pear-scab is but a form of that which produces a similar disease of

the apple. It has the same habit of growth, produces similar effects and may be combated in the same way. Figure 295 is drawn from one of the young pears sent us by Mr. Mann. It is badly spotted and the fungus has extended well along the stem. The leaves received were also much spotted and occasionally the parasite was growing on the leaf-stalk and also on the young shoots. Allowing the leaves and fruit to fall or be removed, the fungus still remains upon the tree on the smaller shoots living there through the winter ready to infest a new crop of leaves and fruit the following season.

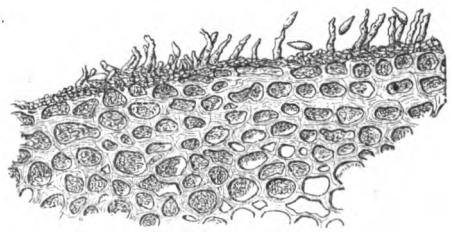

Fig. 294. Section of portion of the leaf stem showing fungus growth upon the surface.

Figure 294 illustrates a small section from a leaf-stalk as seen under the microscope. On the upper or outer surface there is a strong growth of the fungus with many upright spore-bearing stalks and several spores. The discolorations of the contents of the underlying cells extend to the depth of several layers as indicated by the shading within the cells.

As to the opinion that the electric storm of June 5 caused the destruction of the crop, Mr. Mann's statement that his fruit was ruined before this storm seems to be a sufficient answer. We venture to say that the storm did not in any way directly injure the crop, although it

might for a brief period favor the extension or propagation of the scab fungus.

According to the samples of apples and pears received from Mr. Mann, and the statements made in his communication, the cause of the losses complained of is the fungus named *Fusicladium dendriticum*—the form upon the pear not being specifically distinct. We would call attention to the statement made by Mr. Mann in which he says that he found embryo pear fruits blackened by the fungus before the blossoms had withered. It is not safe, therefore, to delay spraying until the fruit is set. We must begin *early* in the season. Early in April, before the buds have started, the trees should be most thoroughly sprayed with a strong solution of sulphate of iron, or better, perhaps, a solution of sulphate of copper—one pound to eight or ten gallons of water. Then, just before the blossoms appear, spray again, this time using the ammoniacal solution of sulphate of copper or modified eau celeste. At least two more sprayings should be made at intervals of from ten to fifteen days, and if the season has been cold and wet, an additional spraying may be necessary. In orchards so badly infested as those referred to above, the labor of freeing them from the *Fusicladium* will be considerable and involve much patience and care, but the treatment is inexpensive, thoroughly practical and certain to prove successful; if not completely so, at least to a degree sufficient to amply repay the undertaking.

CHAPTER XV.

THE ENTOMOSPORIUM OF THE PEAR AND QUINCE.

(*Entomosporium maculatum*).

There is a fungus which attacks both the pear and the quince—young shoots, leaves and fruit—named by mycologists *Entomosporium maculatum*. It has been variously named "Leaf-blight of the Pear," "Cracking of the Pear," "Quince-leaf Blight," etc., by popular writers, but as the term "blight" has been applied to a great variety of fungus diseases, and in the case of the pear is applied to a special disease caused by an organism very different from the Entomosporium, its use is ambiguous and likely to lead to confusion. We think it best to adopt, in the present case at least, the generic name of the fungus (*Entomosporium*) adding the name of the plant attacked, to indicate which particular species of the genus is meant.

This fungus, or the disease which it occasions, has been known both in this country and in Europe for many years and something is said about it in all our more important works on the pear or quince. It is very fully described and illustrated in the Annual Report of the U. S. Dept. of Agriculture for 1888. The figures given here, excepting the quince leaf, were redrawn from those in this report. Last year the disease

was treated successfully for the first time by agents of the Department (See Bull. 11, Sec. Veg. Pathol. p. 46).

We have seen this disease in many parts of the country, on the pear particularly in New Jersey and on the quince wherever we have seen this tree, and our attention has very recently been called to it by the receipt of diseased quince leaves from a correspondent in western New York, who affirms that the fruit of that tree is often destroyed or rendered wholly unfit for market from this cause. Scattered over the leaf-surface and showing on both sides are numerous, usually round, brownish-red spots with sharply defined outlines and a central black point. Often several neighboring spots run together or the leaf tissue between them dies and thus are formed patches of considerable size and irregular outline. Such patches are most frequent along the margins of the leaves, these becoming dried and curled up. The vitality of the leaves is, after a time, seriously affected, they lose their hold upon the branches and fall prematurely. Diseased leaves of both pear and quince are shown in figure 315, the brown spots and patches are indicated by the shaded portions. The spots on the pear leaves are usually smaller than those on the quince, rather darker colored, often less sharply defined and have a reddish discoloration of the tissues bordering them.

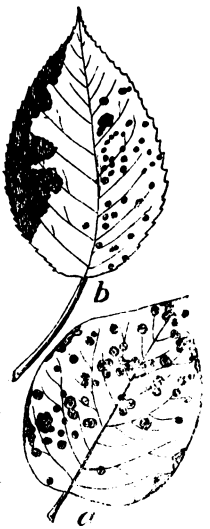

Fig. 315. *a*, leaf of quince. *b*, leaf of pear; each attacked by the Blight.

The fungus attacks the shoots of the season, sometimes so severely as to kill them and, as already stated, the action of this parasite upon the fruit often renders it unfit for market, its growth being checked completely or made distorted and unsightly. In the case of the pear the fungus often confines itself to one side of the fruit and as the other parts continue to develop, this side cracks open to a greater or less depth; hence the name—"Cracking of the Pear"—which we sometimes hear applied to the disease. A characteristic example of this cracking of the fruit is shown in figure 314.

Fig. 314. Cracking of the Pear, caused by the Entomosporium.

This *Entomosporium* is to the pear and quince growers a very serious pest. Its attacks begin very early in the summer and continue throughout the season. We have seen quince trees defoliated from its ravages by the first of August and have heard of cases of young pear orchards being entirely stripped of their leaves by July 4, from the same cause. Such a wholesale destruction of the foliage cannot fail to materially injure the vitality and longevity of the trees themselves and certainly diminish the product of succeeding crops. It is on young nursery stock that the disease is most severe, in fact, nurserymen have not infrequently been forced to give up the propagation of the pear on account of its great destructiveness.

In order to see the characters of the fungus which does so much injury we make a very thin section through

one of the black points found in the center of the brown spots, for it is in these that the fungus reaches its fruiting stage, and examine it under the microscope. In this manner we get a view like that shown in figure 313. Below are the long palisade cells of the leaf tissue upon which rests the epidermis. These cells are much shrunken and their contents changed to a dark brown. Growing between them may be seen a number of slender filaments that constitute a part of the mycelium of the fungus which is shown more plainly above, just beneath the cuticle, which it has broken through. Here are seen in various stages of development the very peculiar spores. Several of these spores, detached from their supports, are also shown in the figure. As seen under the microscope the spores have somewhat the appearance of minute insects and it is from this resemblance that we get the name *Entomosporium*, or *insect-like spores*. Upon the fallen leaves which have suffered from the disease there has been found during the later winter or early spring months, a fungus growth thought by some to be the mature or perfect stage of development of our *Entomosporium*. In this stage the spores are two-celled and enclosed, usually to the number of eight, in delicate, elongated sacs, all being surrounded by a rather dense and hard black covering. These well

Fig. 313. Fungus of Pear-leaf Blight and Quince-leaf Blight. Also causes "Cracking" of pears. *m*, mycelium, *s*, spores.

protected spores, if really belonging to the *Entomosporium*, assist in the propagation of the fungus and are doubtless designed to preserve it from destruction by accident or through the severity of the winter season.

TREATMENT.

Very little can be done in preventing the ravages of this *Entomosporium* by pursuing special methods of culture or by selection of varieties, although in certain localities some varieties appear to be more resistant than others. Happily, however. the disease responds readily to treatment with the sulphate of copper compounds. The Bordeaux mixture applied early in the season, as soon as the first leaves are formed, and repeated at intervals of from ten to fifteen days, has completely preserved the foliage on seedling pears in nurseries where the young trees not so treated were denuded of leaves by mid-summer. By a similar treatment of older trees —both the pear and the quince—have been preserved from the disease in orchards where untreated trees suffered severely. In addition to this treatment during the growing season we would recommend that the trees be sprayed with a simple solution of sulphate of copper (1 lb. to 5 gals. of water) just before the buds begin to swell in the spring.

CHAPTER XVI.

PLUM-ROT OR THE MONILIA OF FRUIT.

The Monilia, or as it is sometimes called, the Oidium, of fruit (*Monilia fructigena*), is a fungus widely distributed in this country and is especially destructive to stone fruits, peaches, plums, etc., in the Middle and Southern States. It was particularly prevalent in this vicinity last summer, seriously injuring the peach crop. At the time when the peaches were ripening, there were almost daily showers and the weather was hot and sultry, conditions especially favoring the growth of the *Monilia*. Frequently the entire product of a tree was attacked and practically destroyed before the fruit was ready for harvest, and of some of the choicer early varieties it was often difficult to secure for eating a single peach wholly free from the fungus. In a single county in Maryland, the loss of peaches in 1888 from this rot, was estimated to be 400,000 baskets or $200,000. When we consider that this parasite attacks plums, cherries and apricots as well as peaches, the moneyed loss to the entire country which it may occasion, and which it annually does occasion, must be very great. Without data we can make no definite estimate of the amount, but we already know enough to appreciate the gravity of the disease and the importance of using every effort to combat it.

The *Monilia* appears upon the surface of affected fruit as mealy or grayish white patches of greater or less extent, usually on the side most exposed to the light. Examined closely, these patches are seen to be made up of a number of little tufts, forming an unevenness of surface in the larger patches of fungus growth. This growth consists for the most part of spores which are borne in chains or one above another on comparatively short stalks (see figure 267, which is designed to illustrate one of the tufts above mentioned). The mycelium of the fungus grows among and through the cells composing the tissue of the fruit, turning them brown. Wherever this mycelium comes to the surface spores are formed, by a constriction of the mycelial threads, in great abundance. It would seem that the fungus in a single affected peach or plum might produce many thousand and perhaps millions of spores. These spores, blown about by the wind or washed by rain from fruit high up on a tree to that lower down, may each one of them infect healthy fruit. If the temperature is high and the spores fall in a drop of water on the surface of a healthy peach or plum they will quickly germinate and the germ tube will bore its way through the skin of the fruit, thus infecting it and rot will follow. If the skin of the fruit is broken in any way, infection is made more certain and rot follows more quickly. In the case of the apple it appears to be necessary to infection that the skin be previously broken.

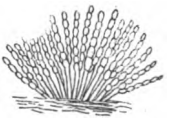

Fig. 267.

The fungus lives over the winter season in the fruit which it has destroyed through the summer, and possi-

bly also in the twigs of the trees as these are sometimes infested with it. On the first of last January, the weather at the time being unusually warm and damp, we found this fungus producing spores on dried peaches that were still adhering to the trees. We inserted some of these spores in two slight incisions, about two inches apart, in an apple, and at the same time placed some of them in a drop of water on the apple where the skin was unbroken. The apple was then placed under a bell-jar where it was kept moist. In two day the spores in the incisions had germinated and the mycelium had grown sufficiently to produce new spores. Two of these mycelial threads bearing spores are shown in figure 266, and to the left is shown a single spore which has pushed a germ-tube. On the third day after inoculation the tissue immediately about the incision had commenced to turn brown and within a week this discoloration, extending from each incision had met, forming one large brown "rotten" spot. The mycelium of the fungus was found throughout all the tissue between the points of infection. The spores planted on the uninjured skin failed to develop.

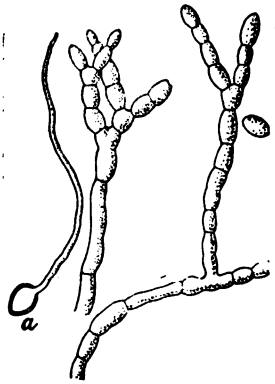

Fig. 266.

In regard to the action of this *Monilia* on the twigs of the peach Mr. Erwin F. Smith, (in the *Journal of Mycology* Vol. 5. No. III.) says:

"When the rot appears in the twigs it is commonly

called 'blight.' I first discovered this blight in the summer of 1887, in Delaware, where it was unusually prevalent. Trees thus attacked present a very peculiar appearance, quite suggestive of blight in the apple and pear, only in the peach the destruction appears to be confined principally to the twigs, the injury seldom extending to branches which have formed more than two annual rings. * * * In summer and autumn the blight of peach stems is always, or almost always, traceable to infections derived from mycelium. * * * This mycelium originates in the rotting peach; bores through the pedicel into the stem; ramifies in the latter, especially near the place of entrance and quickly destroys all the distal portion of the branch. * * * The earliest varieties blight most, and trees not in fruit never blight at this time of year. * * * In wet seasons it [this twig blight] sometimes does more injury than the rot, because when many branches are destroyed the tree is not only injured, but the next year's crop is proportionately reduced."

TREATMENT.

Owing to the rapid development of this fungus, and the fact that its presence does not become manifest until it is in the act of multiplying itself by spore-production, little can be accomplished by direct treatment. The spore formation may be checked somewhat by the application of sulphur but the destruction of the fungus growing within the tissues of the fruit, can only be accomplished by the complete destruction of the fruit itself. Possibly, if the fruit is sprayed before infection has taken place, with some fungicidal solution that will adhere well to it, like the ammoniacal solution of car-

bonate of copper, the disease may be prevented to some extent. We deem this worth trying.

As a means of guarding against the disease, and one which ought always to be practiced, all affected fruit should be gathered as soon as observed and destroyed or buried deeply in the ground. No diseased fruit should be left on the ground or hanging to the tree for it is from these that the fungus is able to breed disease in a succeeding crop. When the twigs are affected they must be cut off and burned, for in them the parasite may live from year to year. To be wholly successful this course of treatment must be vigorously and persistently followed, not only by individual fruit growers but by all concerned. The spores of *Monilia* allowed to form in the orchard of the negligent, may be wafted by the wind or carried by insects to that of the thrifty, and all the care and labor of the latter may thus be lost. Those in peach growing districts can ill afford to neglect this subject or rest in their efforts until a concert of action is enforced.

CHAPTER XVII.

BLACK-KNOT OF THE PLUM AND CHERRY.

Black Knot or "Wart" of the Cherry and Plum are descriptive names of a special fungus disease of these trees consisting of knot-like or wart-like growths which appear on the smaller limbs as well as on the larger branches and sometimes even on the trunk. In many sections of the country, particularly in the Eastern and Middle States, it is one of the most serious obstacles to the successful culture of these fruits, for a tree which has once become affected with the knot rarely survives for more than a few years, and it may become so badly diseased in a single season as to be no longer a source of profit.

The fungus which causes the growth of the knots was described in its mature stage sixty-eight years ago by the celebrated mycologist, Schweinitz, who, however, seemed to think that the knots were caused by some gall-producing insect rather than by the fungus which he found upon them. Many have supposed them to be the result of insect attacks, and not without some apparent reason, for upon cutting open the knots one will very frequently find in them the larvæ of certain insects. Several species of insects have been thus observed, but none of them belong to the gall-producing sorts, and there is no longer any question as to the real cause

being a parasitic fungus. This fungus is invariably found growing in and fruiting on the knots and *nowhere else*. The life history of this fungus has been very carefully studied by Dr. W. G. Farlow, who published an account of its habits and means of reproduction, in the Bulletin of the Bussey Institute, in 1876. Previous to this there was really very little known concerning this parasite, and even now many of our fruit growers do not appear to understand the nature of the disease.

Fig. 1585.

We have in hand some specimens, recently received from New Jersey, which well illustrate the disease in its advanced condition and show how serious it may become. Figure 1585 was drawn from these specimens and fairly represents the external characters of the fully developed knots. The curving or change of direction of growth of the more slender branch in the figure, is caused by the fungus, its action having been to produce a more rapid growth of the cells on the convex side which is covered by the knot. In some cases the knots are proportionately larger than those which we have drawn, and in some of the samples they completely surround the branches. There is no bark

over the knots excepting, perhaps, here and there a fragment which has been carried up with their growth, and surrounding the base of the knots, the raised and broken edges of the bark show that they originated beneath it.

Upon a close examination of the black and more or less irregular surface of the knots they are seen to be densely covered with slightly elevated and rounded projections which give to the surface a roughened or pimply appearance. Each one of these little pimples is a mature fruit of the fungus. Making a vertical section through one of the knots together with the stem which bears it, we find within the thin black layer that covers the surface a mass of spongy and more or less porous tissue which evidently has its origin in the cambium layer,—the living, growing layer between the wood and the bark. There is little or no discoloration or malformation of the wood itself. In some of our specimens the wood beneath the knots was injured considerably but it was through the action of insects which had found a convenient lodgment in the knots. In the interior of the knots there were cavities of greater or less size which were also the work of insects. Examining the loose, spongy tissue with a compound microscope it was found to be made up of enlarged and very irregularly formed woody cells through which were scattered, sometimes thickly, sometimes quite sparingly, the slender threads of the mycelium of the fungus which had caused the distorted growth. This mycelium is clear and colorless excepting near the surface, where it rapidly becomes dark brown and finally black, forming over the knots a dense, black,

crust-like covering. The formation of the knots appears to be entirely due to the action of the fungus on the cells of the cambium—these having been excited into a very rapid and irregular growth.

In our vertical section through one of the knots we notice, if we look sharp, that where the cut passes through the little pimples above referred to—and we can make no cut without bisecting a number of them—each of these appears to be filled with some white substance. (In the older knots they present only an empty cavity in the center.) A section cutting through three of these pimples is illustrated, enlarged, in figure 1591.

Fig. 1591.

Placing a bit of this white substance under the microscope its nature is clearly brought into view and we see, as we have already said, that the little pimples are the fruits of the fungus. They are called perithecia, and lining the cavity of each is a delicate tissue composed of small transparent cells; growing from this and directed toward the centre are a great number of elongated club-shaped bodies, abruptly narrowed at the base or near their point of attachment. These are simply transparent sacks within which the spores are formed, the number of the latter in each sack being eight. Mingled with these spore-containing sacks are many long and slender, thread-like growths that are slightly enlarged at their tips. Figure 1590 is reproduced from a very much enlarged drawing of these spore-sacks with their intermingled threads, taken from one of the perithecia shown in section in figure 1591. Within the sacks the spores are clearly visible. The latter, shown separately in figure 1592, where two of

them are seen to be germinating, are elongated-oval in shape, broadest above. Near the narrow end is a transverse wall or septum which divides the spore into two very unequal cells. The smaller of the two cells is much thinner walled than the other and appears to be rather an appendage to the spore than a part of the spore itself.

Such are the characters, briefly told, which were exhibited by the specimens of black knot received from New Jersey, or which can be seen in any of the knots in April or very early May. Just at what season the spore-sacks and spores which we have described and which belong to the *mature* state of the fungus, are formed, we cannot positively say, but it is probably during the later winter months, or in those of early spring. At this season (the first of May) they are evidently ripe and ready to reproduce the fungus whenever they shall escape from their sacks and find a proper lodgment on the bark of some plum or cherry tree. That they do germinate upon the bark and by some means gain access to the cambium layer beneath it, the spread and development of the knots testifies.

Fig. 1592.

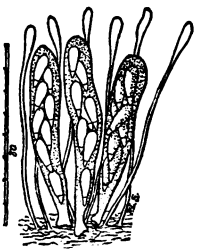

Fig. 1590.

There are, however, other reproductive bodies produced by the fungus of black-knot which may afford even a more ready means for the propagation and spread of the disease than that mentioned above. We will briefly follow the course of development of the knots and note these spore-forms in the order of their

succession. It is stated upon good authority that the first manifestation of the knots is in the fall and appears as a slight swelling of the bark along the branches. These make but little growth until the following spring, when they enlarge rapidly, attaining nearly their full size in a few weeks. We have never noticed the swellings in the fall, but we have observed their development in the spring, which is often surprisingly rapid at about the time the trees are first in full leaf. The length of time between the period of infection, that is, from the germination of the spores and their penetration of the cambium layer, and the first external manifestation of the disease is not known nor do we exactly know the conditions that are most favorable to the growth of the fungus. Doubtless moisture is necessary to effect the germination of the spores, and it is probable that the knots will form most quickly in trees which are under high culture and growing rapidly. We are inclined to believe that, although infection may occur in the fall or during the latter part of summer, it also may take place in very early spring through the agency of the spores, already described, which are ripe at that season.

For a time the bark over the forming knots expands with their growth, but it is finally burst asunder, exposing the diseased growth composing them. About the first of June, in the latitude of New Jersey, this exposed surface presents a velvety surface of a dark olive-green color. This is dne to the growth of a vast number of spore-bearing stalks all over the outside. Three of these stalks, with their spores attached, are shown in figure 1589. Considering the vast number of these reproductive bodies, borne upon every newly

developed knot, it is a wonder that any tree escapes the disease.

As the season advances the surface of the knots becomes roughened and pimply, much as we have seen it in the mature specimens, and at this period these pimples are the receptacles for another kind of spore termed stylospore. These are oval or oblong in shape and are divided by transverse partitions or septa into three cells. They are all borne on very slender stalks, as shown in figure 1588, where several of these stylospores are illustrated, very much magnified. The fungus continues alive and active in the knots throughout the summer and following winter, when the spore-form first described is produced, after which it dies and we have left a mass of dead tissue which may afford protection or support for various insects, and these may, and usually do, add to the injury already occasioned to the tree.

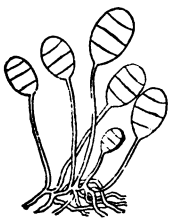

Fig. 1588.

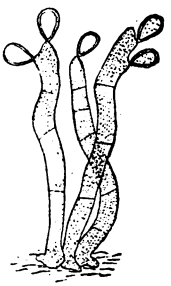

Fig. 1589.

From what has been said, we learn that the fungus of Black-Knot is abundantly supplied with means for reproduction and we cannot too promptly remove and destroy the knots whenever and wherever they appear, not only from our cultivated varieties of cherry and plum trees but from the wild varieties which are also attacked by the parasite. The knots on a single wild tree will produce spores enough to infest the cultivated trees of

an entire county. Badly diseased trees, of either sort, should be cut down and the knots burned or otherwise destroyed at once. When there is only here and there a branch that is diseased, these alone may be removed, the knots destroyed and the trees then disinfected by a thorough washing with the Bordeaux mixture; or, if the work be done in winter, with a very strong (30 to 50 per cent.) solution of sulphate of iron. These solutions, if well applied with a strong force pump, will doubtless destroy or at least prevent the germination of any of the fungus spores that may be resting on the bark awaiting suitable conditions for development. The same solutions, if applied directly to the newly developed knots, would probably prevent the formation of the spores but would not be likely to check the growth of the fungus occupying the deeper tissues. The spread of the disease might thus be prevented but the injury then going on could not be checked. The knots ought to be removed on account of the attraction they offer to insects, if for no other reason. When the swellings appear on the larger limbs and trnnks of the trees, cut them out carefully, extending the cut from two or three inches above and below the knots and then paint the wounds, first with a strong solution of iron sulphate and then with some oil paint.

From the contagious character of the disease it can be stamped out only by a concerted action, and the extent of the losses occasioned by its ravages make it a proper subject for State consideration.

CHAPTER XVIII.

LEAF-SPOT DISEASE OF THE PLUM AND CHERRY.

(*Septoria Cerasina*).

The leaf-spot disease of the plum and cherry has occasionally been mentioned in our horticultural journals as the "shot-hole" disease or "shot-hole" fungus, and one writer describes it under the name of plum-leaf fungus. The fungus which causes this disease is very generally distributed throughout the States east of the Mississippi. It attacks the foliage, and although not regarded as a serious pest, it often inflicts considerable injury both to the cherry and plum by interfering with the proper functions of the leaves or by causing these to drop prematurely, sometimes as early as the first of August. The leaves attacked show, at first, scattered here and there over the surface, dark purple spots visible on both sides, varying from 1-24 to 1-8 of an inch in diameter. After a brief period it will be noticed that the tissue covered by some of these spots has become dead and brown in color. Such

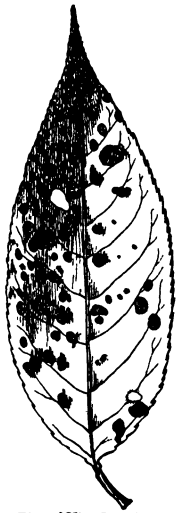

Fig. 327. Leaf-spot disease of the cherry. A spotted and discolored leaf.

spots usually have their margins clearly defined and are most often circular in outline. Sometimes this dead tissue drops out from the leaf leaving a clear cut, round hole, giving the leaf the appearance of having been perforated by shot holes, hence the name sometimes given to the disease, mentioned above.

If we examine one of the brown spots under a lens, we will usually detect upon the under surface one to several very minute black points. These points are the fruits of the fungus—little capsules within which the spores are produced in great abundance. They, the spores, are very slender, many times longer than broad, and quite transparent. They are usually divided by one or more cross-walls into two or more cells. These spores serve to propagate the fungus; each cell in every spore being capable of producing a new growth of the parasite. It is thought that the fungus continues its life and completes its development upon the same leaves which it first attacks, after they are fallen to the ground. The spores produced on the old leaves in the spring serve to propagate the fungus during the new growth of the parts it infests.

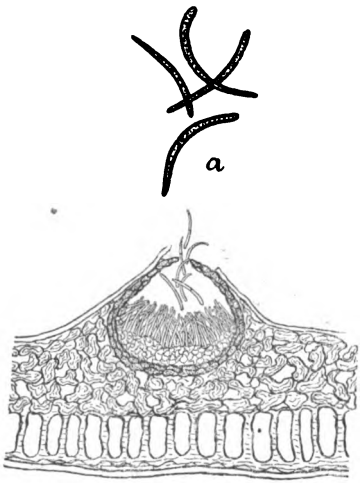

Fig. 323. Magnified section of cherry leaf showing fungus causing Leaf-spot disease; *a*, four spores more highly magnified.

All infested leaves are more or less discolored with the purple or brown spots mentioned above, or they may turn before falling to a clear yellow color. In figure 327 is shown a leaf of the cherry attacked by this fungus, exhibiting a spotted appearance, the shaded left hand side representing a part of which has become discolored through the action of the parasite upon the leaf tissue. Figure 323 represents a highly magnified section through the leaf, including one of the spore capsules; and at *a*, above, are shown some of the spores still more highly magnified.

We do not know that any direct attempts have been made to prevent the disease here described. The parasite is one which buries itself in the leaf-tissues, and consequently whatever treatment is given, it must be *preventive*. If the trees are sprayed with the sulphate of copper compounds for the purpose of preventing plum-rot or the Monilia of fruit, it will be well to observe what effect these applications have upon the development of the Leaf-spot fungus.

CHAPTER XIX.

POWDERY MILDEW OF THE CHERRY.
(*Podosphaera oxycanthæ*).

We have already, in our descriptions of the Powdery Mildew of the vine, explained somewhat the peculiar characters of these parasites and their course of development. They are a widely distributed group of plants —we must remember that fungi are plants—and live upon, or as we are in the habit of saying, *attack* many of the higher forms of vegetation, such as the apple, cherry, rose, oak, etc., deriving their own nourishment at the expense of these. That is, they live upon them as parasites and in the course of their growth they inflict more or less injury to the plant supporting them.

One of the species, described many years ago by a French botanist, for it is as common in Europe as it is in this country, attacks our cherries, both the wild and cultivated species; and also, for it does not seem to be very particular in its tastes, the plum, apple, hawthorn, species of Spiræa, blueberry, and the persimmon. It appears to prefer young and tender plants and shoots, and it is to these that it is the most harmful. Young nursery stock and the sprouts which spring up during summer around old trees are particularly subject to its attacks.

Like other plants of the class to which it belongs, it

lives upon the outside of its host, obtaining the food it requires by means of little suckers—the botanist calls them *haustoria*—which it pushes through the cuticle into the epidermal cells, as shown in our figure. Over the surface of a leaf it spins, as it were, a white, felt-like coating, more or less thick, consisting of very slender interlaced filaments — the mycelium that forms the "plant body" of our Powdery Mildew. From these filaments there arise upright stalks, each bearing a succession of spores (called conidia) which fall off, one by one, as they mature, from the apex. Several of these conidia-bearing stalks and the mycelium are shown in figure 352.

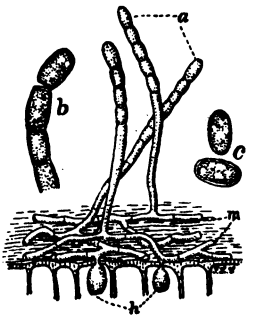

Fig. 352. Powdery Mildew of the Cherry. *m*, Mycelium extending over surface of leaf. *h*, Haustoria in epidermal cells of leaf. *a*, Conidia on Conidia-spores. *b*, Conidia nearly mature. *c*, Detached, mature Conidia.

The fungus grows upon both sides of the leaves, although there is usually less of the white coating visible on the under side. It is upon this lower surface, however, that we have most frequently found the mature fruits of the plant. These fruits are barely visible to the naked eye, appearing like a multitude of minute black specks. Viewed under the microscope, they are truly elegant objects. Figure 350 illustrates one of these fruits, as seen from above; there is a dark, round, central body (the *perithecium*), to which is attached a number of curiously tipped appendages. These appendages vary considerably in length and number, and while some are simply rounded at the free ends, others are more or

less extensively and symmetrically branched, as shown in the figure. They are all quite dark in color for two-thirds their length, beyond which they are transparent.

Within the central body is a single, very delicate sac (see *a s*, figure 350), which, in turn, encloses eight ovoid or oblong spores—the *ascospores* or *sporidia*. These ascospores, thus securely wrapped, first by the strong walls of the perithecium, then by the thinner membrane of the sac or ascus, are well protected from injury by accident or severe winter weather, through which season they are designed to pass. In spring or early summer the ascospores escape from the case-like perithecium by the natural decay of the latter, and happening to be carried to some young plum or cherry leaf, they start a new growth of the parasite.

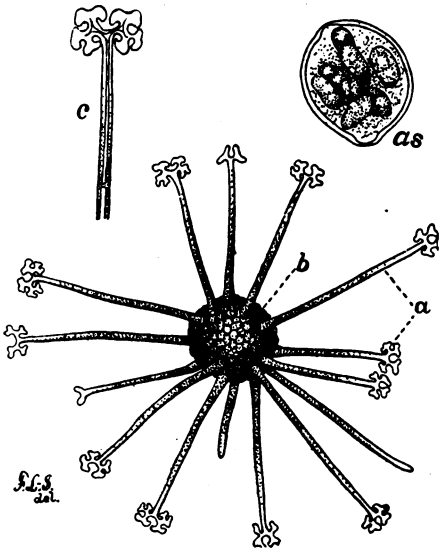

Fig. 350. Powdery Mildew of the Cherry. *b*, Perithecium seen from above. *a*, Appendages. *c*, Terminal portion of one of the appendages more highly magnified. *a s*, Asens showing ascospores within.

TREATMENT.

As the entire plant body of this fungus is exposed to any direct application made to destroy it, the treatment is a comparatively simple matter. Treatment should be made before the formation of the mature fruits, as these are far less easily destroyed than the simple mycelium or conidia. The flowers of sulphur, properly applied, will destroy these. A good effective liquid remedy for this, as well as other Powdery Mildews, is a solution of liver of sulphur (sulphuret of potassium), one-half ounce to the gallon of water. This solution ought to be used as soon as prepared, and it is best applied warm.

CHAPTER XX.

PEACH-LEAF CURL.
(*Taphrina deformans*).

The peculiar disease of the leaves of the peach known as "Curl," is familiar to all growers of this fruit. It is wide-spread both in this country and Europe, probably occurring wherever the peach is cultivated, and although not generally regarded as a serious malady, the damage resulting from it is by no means insignificant. It often severely injures nursery stock, and young, thriftily growing trees are more subject to its attacks than those which have reached a degree of maturity. Young trees, obtained from New York nurseries and planted here* last year on the University grounds, have been very badly affected with the "Curl" this season. Nearly 50 per cent. of the first leaves formed were destroyed and the attack was not limited to the foliage; the disease extended to very many of the young and rapidly grow-

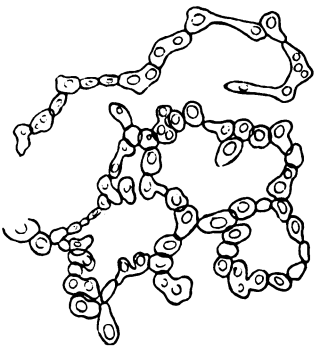

Fig. 1595. Mycelium of the Peach-leaf Curl Fungus.

* Knoxville, Tennessee.

ing shoots, and all such were killed before the first of June. The older peach trees in the neighborhood, grown here from pits, have shown the disease but rarely, only here and there a single diseased leaf.

The "Curl" is limited in duration to the period when the young shoots and leaves are most tender; after the tissues of these parts are fully formed or matured they are no longer affected. The disease becomes manifest as soon as the first leaves are expanded and, in this latitude, its course is run before the end of May. By the first of June the only signs of the malady are the withered leaves scattered on the ground and the dead and shriveled shoots on the tree; new leaves have already been developed on laterals which have grown from the branches below that portion killed by the disease. On some of the dead twigs there is a gummy exudation, probably the product of unassimilated sap.

The illustration (figure 1600) shows the characteristic appearance of a peach leaf affected with the "Curl," and the same figure illustrates a twig diseased from the same cause. Such leaves are too familiar to our readers to require a detailed description; we would only add that not infrequently the entire leaf is involved, especially those not more than half grown, and when this occurs the leaf is usually curled or twisted upon itself. We have often seen a half dozen or more such leaves clustered at the ends of the young shoots. The diseased leaves or parts of leaves affected are somewhat thicker and of a more fleshy texture than those in health. The under surface of the diseased parts is usually smooth but the upper surface has a more or less mealy appearance. Sometimes, though rarely, this mealiness is seen

on the under surface of the leaf, but we have never seen it on the diseased leaf-stalks or shoots. The surface of the latter is always smooth. When the leaf-stalks are affected they are swollen to several times their normal thickness and seldom attain their full length. On the shoots the disease may be limited to a portion of the circumference or, as is more often the case, involve the entire surface. These shoots have a pale green color, are much thickened, the surface being irregularly swollen and in the end they die and turn black.

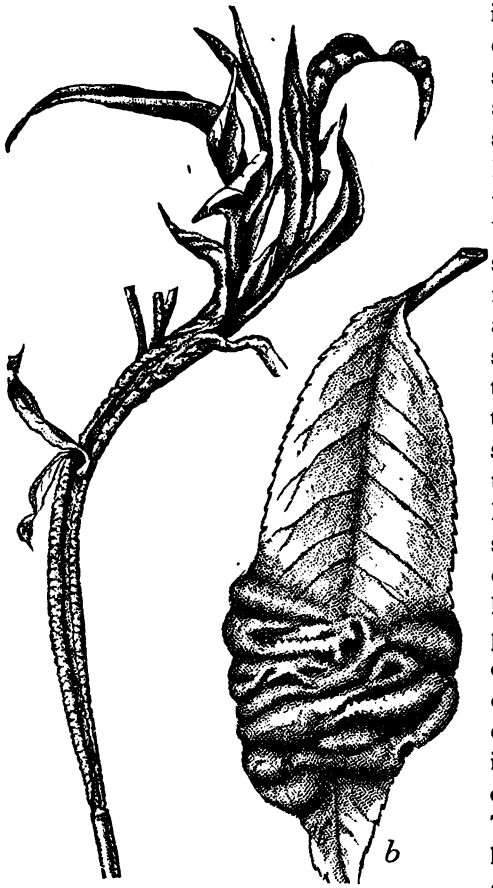

Fig. 1600. Peach-leaf Curl. *a*, Diseased shoot. *b*, A diseased leaf.

The cause of Peach-leaf Curl is a minute fungus which the mycologists have named *Taphrina deformans*. This fungus is closely related to, in fact possesses all the essential characters of *Taphrina pruni*, which causes the inflated and bladdery "plum pockets." In the tissues of the diseased parts, most readily in the leaves, one may see the mycelium of this fungus—the *Taphrina deformans*—extending its growth between the cells and sometimes even passing through them. In the deeper tissues the threads are scattered and of very irregular growth (see upper fragment in figure 1595). Just beneath the cells of the epidermis of the leaf the mycelium is more abundant, but in no part is it so profuse as between the epidermis and the cuticle. Here it forms a perfect net-work of threads, which, owing to the shape of the individual cells composing them, resemble strings of irregularly formed beads. A bit of this peculiar mycelial growth, taken from between the cuticle and epidermis of the upper leaf-surface, is shown in figure 1594. It is from the cells of this mycelium that the fruiting or spore-bearing sacks of the fungus are developed. These are produced in great numbers, growing up through the cuticle and imparting to the surface the mealy appearance already referred to. An exceedingly thin section made vertical to the leaf surface, is shown in figure 1594. Fragments of mycelium are seen in the tissues, as at *d*. Between the cuticle and the epidermis are a few of the bead-like cells, *c*, of the net-work described above. A young spore-sack is shown at *b*, while at *a*, is a more mature sack containing spores in formation. The number of spores produced in each sack is usually six or eight. The spores doubtless serve

to spread the disease from leaf to leaf and from tree to tree, but all efforts made to produce infection artificially have so far failed of results. Nothing really is known of what becomes of the spores or of the fungus, after it has run its course and the effects of its ravages have disappeared. It is probable, however, that portions of the mycelium remain dormant in the tissues of the tree near the buds from one season to the next, awaiting the tender, spring growth to produce anew the disease. It is evident that it is only possible for the fungus to attain any marked development except at the commencement of the growing season when the tissues of the young trees are succulent and most tender. When these tissues reach a certain degree of firmness the fungus has no longer the power to penetrate between the mature cells. It is not necessarily wholly destroyed, but, as just stated, remains dormant awaiting the return of conditions favorable to its growth.

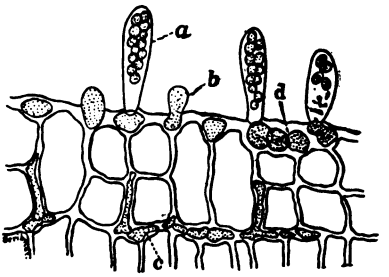

Fig. 1594.

So little is really known of the life history of this *Taphrina* that not much can be said relative to preventing its attacks. Removing and destroying all the leaves and young shoots as soon as ever they show any signs of the malady and, at the proper season, cutting well back the branches whereon the disease existed, is the most rational course to follow that suggests itself.

Such treatment ought certainly to mitigate the evil. As an experiment, we would suggest also that the trees be washed or sprayed in March or before the buds begin to swell, with a strong (30 or 40 per cent.) solution of sulphate of iron.

CHAPTER XXI.

THE FUNGUS OF THE RASPBERRY ANTHRACNOSE.

The disease of the raspberry here called Anthracnose, but generally known as Raspberry Cane Rust, is quite destructive in some parts of the country, particularly in the Northern States. Public attention was first called to this disease by Prof. T. J. Burrill, who published an account of it in the *Agricultural Review*, for November, 1882. It was made the subject of a chapter in the Annual Report of the U. S. Department of Agriculture, 1877, p. 357, where it was illustrated by a colored plate. The fungus causing the disease was described by Mr. J. B. Ellis in the third volume of the *Journal of Mycology*, p. 129.

FIG. 249.

The samples from which the following description and figures are made were received from Wisconsin. These presented the characteristic white or grayish, flattened or depressed spots, one to four lines in diameter, bordered by a ring ofdark purple, scattered thick,

ly along the canes (figure 249). The bark (cuticle) over many of the spots had split, and in the older ones the cracking had extended nearly or quite to the pith. At a few points several of the spots had united, forming diseased patches of considerable extent.

In the centre of some of the spots could be seen a slight elevation, yellowish in color and somewhat translucent. These indicated the presence of spores. Through the center of one of these spots a very thin longitudinal section was made and the appearance of this section under the microscope we have attempted to illustrate in figure 1579. This section extends through the cambium layer, the part chiefly affected, and includes some of the woody tissue shown at the bottom of the figure. To the left the condition of the tissue is nearly normal excepting that the cell walls are somewhat discolored to shades of brown. Over the diseased portion the bark is entirely destroyed and the cambium layer beneath is much broken, the remaining cells are more or less shrunken and distorted. The body of the fungus occupies the portion near the surface and at *a*, *a*, it is seen to be fruiting or producing spores. The mycelium

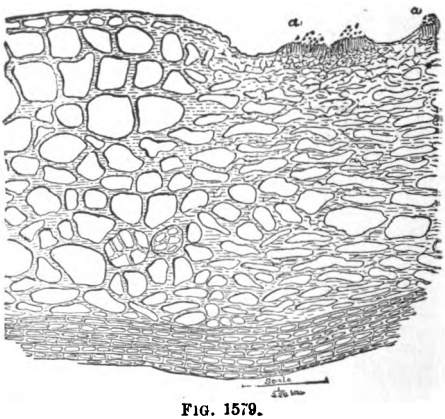

FIG. 1579.

was manifest only near the surface and was particularly abundant just beneath the fruiting points where it appeared to be so dense as to form a compact layer of tissue.

The spore-bearing stalks appeared as represented, shown more highly magnified in figure 1578. As illustrated in the last figure the relative size and shape of spores is given, but they are, for a time at least, embedded in a transparent gummy substance. This gum dissolves in water and when thoroughly dried it soon disintegrates; in either case the spores are set free to find a lodgment upon and convey infection to new points.

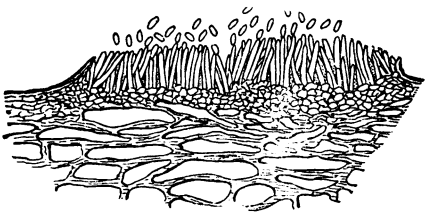

FIG. 1578.

After having been laid aside for some months the specimens we had received were moistened with water and then placed under a bell-jar for a day or two in order to keep them moist, and in this time many of the diseased spots had developed a new crop of spores. This shows the strong vitality of the fungus and at the same time the necessity of entirely removing from the field and burning the diseased canes if we would get entirely rid of the parasite.

The striking similarity of characters between the fungus under consideration and that causing Anthracnose of the grape will be observed by comparing figure 1578 with figure 1511 (see page 74). This similarity suggests the possibility of overcoming it by

the same methods. Both attack all parts of the plants they respectively infest—stems, leaves and fruit. If we can prevent their gaining a foothold on the stems there will be little difficulty in protecting the other parts, as the source of infection will, for the most part, be removed.

Anthracnose of the grape has been successfully combated by washing the vines while dormant with a very strong (50 per cent.) solution of copperas (sulphate of iron); this treatment being followed during the growing season by applications of sulphur and powdered lime in equal parts. So we would treat our raspberry patch if anthracnose had attacked the plants. Clean out the diseased canes and burn them. Wash the canes before the buds begin to swell in the spring with the sulphate of iron solution, and then, when the leaves are well out, dust the plants with the sulphur and lime when the dew is on, or spray them with the Bordeaux mixture when they are surface dry and the sun is shining. For the summer treatment we would recommend trying, instead of the Bordeaux mixture, sulphide of potassium or liver of sulphur in solution—one ounce to each gallon of water used. This preparation should be used as soon as prepared.

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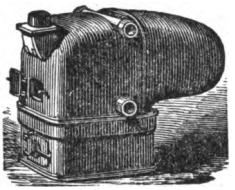

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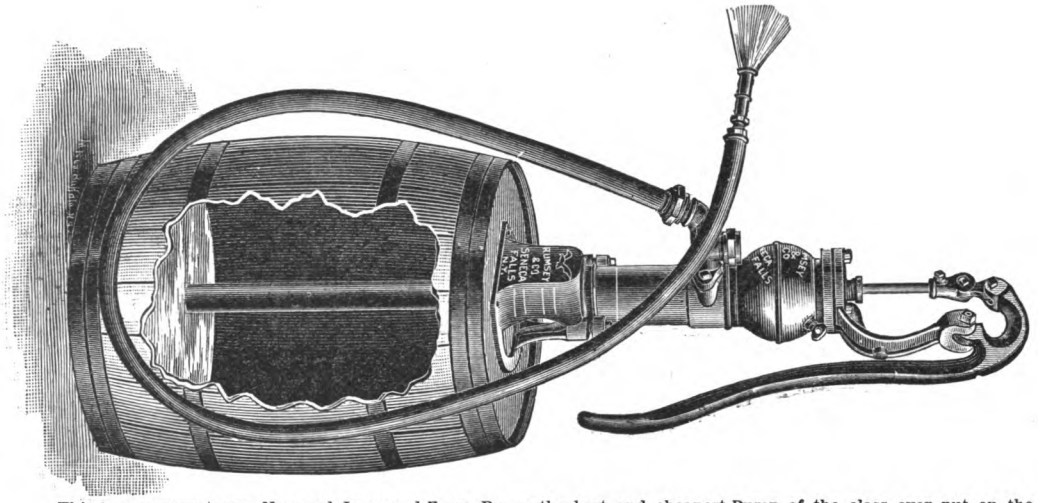

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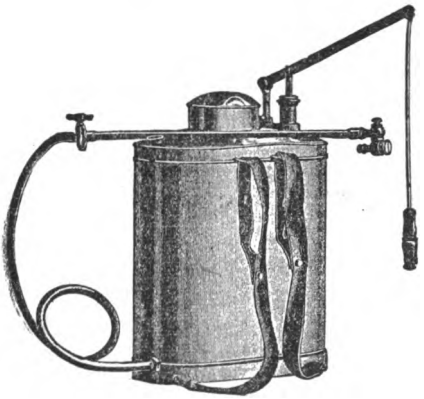

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