Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

Bulletin 222 August, 1920

NEW OR UNUSUAL PLANT INJURIES AND DISEASES Found in Connecticut, 1916-1919

By

George P. Clinton, Sc.D., Botanist

CONTENTS

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

OFFICERS AND STAFF

August, 1920.

STAFF.

Administration.
E. H. Jenkins, Ph.D., *Director and Treasurer.*
Miss V. E. Cole, *Librarian and Stenographer.*
Miss L. M. Brautlecht, *Bookkeeper and Stenographer.*
William Veitch, *In charge of Buildings and Grounds.*

Chemistry.
Analytical Laboratory.
E. Monroe Bailey, Ph.D., *Chemist in Charge.*
R. E. Andrew, M.A., C. E. Shepard, H. D. Edmond, B.S., Owen Nolan. } *Assistant Chemists.*
Frank Sheldon, *Laboratory Assistant.*
V. L. Churchill, *Sampling Agent.*
Miss A. H. Moss, *Clerk.*

Protein Research.
T. B. Osborne, Ph.D., D.Sc., *Chemist in Charge.*

Botany.
G. P. Clinton, Sc.D., *Botanist.*
E. M. Stoddard, B.S., *Assistant Botanist.*
Miss Florence A. McCormick, Ph.D., *Scientific Assistant.*
G. E. Graham, *General Assistant.*
Mrs. W. W. Kelsey, *Stenographer.*

Entomology.
W. E. Britton, Ph.D., *Entomologist: State Entomologist.*
B. H. Walden, B.Agr., I. W. Davis, B.Sc., M. P. Zappe, B.S., Philip Garman, Ph.D. } *Entomologists.*
Miss Gladys M. Finley, *Stenographer.*

Walter O. Filley, *Forester, also State Forester and State Forest Fire Warden.*
A. E. Moss, M.F., *Assistant State and Station Forester.*
H. W. Hicock, M.F., *Assistant.*
Miss Pauline A. Merchant, *Stenographer.*

Plant Breeding.
Donald F. Jones, S.D., *Plant Breeder.*
C. D. Hubbell, *Assistant.*

Vegetable Growing.
———

REPORT OF THE BOTANIST,

G. P. CLINTON,

FOR 1919.

NEW OR UNUSUAL PLANT INJURIES AND DISEASES, FOUND IN CONNECTICUT, 1916-1919.

INTRODUCTION.

In our first Report, for 1903, we gave brief mention of all of the Connecticut plant troubles, not including insect injuries, that had been reported by others or observed by ourselves up to that time. Since then in most of our Reports, additional troubles have been recorded in the same manner. However since 1915, no account, in this general way, has been rendered of the troubles that have come to hand during these four years. It is the aim of the present Report to cover this period, reporting such of these as have been definitely determined.

As in previous Reports we discuss both diseases and injuries, including abnormal or monstrous growths, of all our economic plants. Most of these troubles are caused by fungi and they are indicated here by the common name in small caps with the scientific name, where definitely known, in italics. The other troubles follow these and are indicated by a common name printed in italics. As practically all of these latter are mechanical, environmental or so-called physiological diseases or injuries, they have no scientific name. As in the past these troubles are most conveniently reported in alphabetical order under their hosts, also arranged alphabetically according to their common names with scientific names following.

We shall not attempt here to give in any detail, as previously, the weather conditions of each year and their bearing on the suppression or development of these troubles. It might be well to note in passing that the winter of 1917-1918 was one of the most severe winters since we began our disease survey of Connecticut, and that there resulted great injury to perennial plants, especially to cultivated fruit trees. The injury to the wood and flower buds of peach trees from this and the preceding and

following winters has been such as to put this prominent fruit industry largely out of business. The spring and early summer of 1918 were so wet and the midsummer so dry that very unusual troubles of potatoes, largely physiological, developed. Furthermore the spring and summer of 1919 had so much rainy or muggy weather that an unusually large number of fungous diseases developed, including very serious injury by the late potato blight. The lack of potash in most fertilizers, due to the war during these years, also played some part in the development of unusual troubles, especially of potato and tobacco.

Before proceeding to a specific account of these various troubles, we wish to briefly discuss here two that do not come strictly under the designation of "plant diseases," since while of a fungous nature their injurious activities were directed to the destruction of household timbers in one case, and household butter in the other.

DRY ROT.

Dry Rot Fungus, *Merulius lacrymans* (Wulf.) Schum. We first called attention to this fungus in our Report of 1906, pp. 336-41, where we noted, with illustrations, its action on the wainscoting of a church basement at Stony Creek. Again, in 1916 (Rep. 1915: 424-5.) we reported a vigorous development of the fungus on flooring, boxes, tools and heads of sewing machines at the Singer Mfg. Company's Plant in Bridgeport.

An even more destructive and luxuriant growth of the fungus, than at either of these places, was called to our attention in July, 1918, by Mrs. Robert H. Comstock, who wrote in part as follows: "Five years ago we built a small house on high farm land along the sandy beach of the Sound at Westbrook, Conn. We laid a cement foundation but did not dig a cellar and when the land was graded the cement was almost entirely covered, as we particularly wanted the cottage to set low. For several years we have noticed a fungous growth on the partitions and under some built-in drawers in the middle of the house. This spring we found the floor was rotted out, even the top floor was more than half gone." Plate XXXIII, a.

At Mrs. Comstock's request we inspected this unoccupied shore cottage, a view of which is given here, making a detailed examination as to the cause and the amount of injury. It was readily seen that the trouble was due to the dry-rot fungus, *Merulius lacrymans,* as it was found in good fruiting condition. In fact the spores from the fruiting bodies had developed so abundantly that they had settled as a very evident reddish-brown dust all over the floors and tables except where these were protected by covers so that when the latter were raised a distinct boundary showed between the covered and uncovered surfaces. The cement foundation had practically no openings allowing for ventilation, thus there was a closed air space of about a foot between the wood beams supporting the double floor and the ground. This prevented the drying-out of the air and gave ideal conditions for the development of the fungus when once it got started on the wood. There were no eave troughs to carry away the water from the roof and likewise the water from the ice-box went into the ground under the house, thus increasing the dampness.

Some idea of the destruction of the woodwork can be gained from the two pictures shown here, one with the flooring partially removed. Some of the wood was so rotten as to crumble easily as punk between the fingers. The entire floor of the living room, Plate XXXIII, b, together with the floor joist, had to be removed. Considerable injury in the kitchen, Plate XXXIII, c, under a built-in set of drawers and in an adjacent closet also was evident, and here the fungus had gone up between the walls of the board partitions a short distance. There was no evidence that the fungus had reached the second story. The fungous growth was very luxuriant on the under surface of the floor boards both in its thick, whitish, felt-like mycelium and, in places, in the reddish-brown, laxly-poroid, fruiting surfaces.

The remedial measures suggested were as follows:—The removal and burning of all infected wood and rubbish; the creosoting, if possible, of the new wood used; the building of several sunken areaways, protected only by wire netting, to allow free access of air under the house; the placing of eaves and leaders and a drain to carry away the water from the roof and the ice chest. A year later we examined the cottage and found that

most of these suggestions had been carried out. There was a very good air drainage under the house by five sunken openings, two on one side and three on the other, and part of the earth had been removed making a larger air space. We saw no indications of further development of the fungus. Somewhat similar suggestions were made for the Stony Creek and Bridgeport outbreaks. We have had no complaints of further trouble at either of these places, and so judge that the fungus has been kept largely if not entirely in check. We are convinced from our experience that this fungus depends in great measure for its development upon a fairly small and tightly closed air space next the wood, and a sufficient amount of water to keep the air therein constantly saturated or at least above the normal amount.

MOLDY UNSALTED BUTTER.

The second trouble, see Plate XXXIV, a, that of moldy unsalted butter, was really first called to our attention in 1913. With Mr. Stoddard we made a preliminary investigation of the trouble then and during 1914 and 1915, intending to make a more complete study of it later, but as no complaints have come in since we have not done so. We make this short report here as a matter of record as little has been published by botanists in this country about the trouble.

The first sample sent us was received in the late fall of 1913 from A. L. Kuran of the New Hartford Creamery. In January, 1914, Prof. H. F. Judkins of Storrs sent us a pound package from the Suffield Creamery and another sample from a different source in November. In these and most other samples seen of wrapped butter, there developed on the surface more or less numerous small spots of a blackish and others of a decided reddish color. These were easily determined as due to fungous growths. In all the samples seen these molds did not penetrate very deeply into the butter. One of the specimens which we have kept ever since 1915 in a closed glass jar, now, however, shows the whole surface overgrown with mixed olive-black and reddish growths and the interior entirely changed into a somewhat dried red substance penetrated by mycelium. Concerning the Suffield sample Prof. Judkins, under date of Jan. 7th, wrote in part as follows:—

"I am sending in a separate package a pound of butter which I obtained from the Suffield creamery. You will note that this butter is unsalted and it is a rather long story to tell all the troubles Mr. Totman, the buttermaker, has had with his butter since last spring, so I will not recite them to you now.

"I am very much interested to find out what kind of growth or growths there is on this butter, particularly the red growth. He has never noticed any of this growth on salted butter. He has never noticed any of the growth as long as it stayed in his refrigerator.

"The print which I am sending you was one of a lot, made on November 25th, sent to New Haven and returned to the creamery on December 6th, in practically the same condition that it is in now, showing that the cold evidently checked the growth of the mold.

"In making a careful examination of the prints and molds used by the buttermaker, I ran across four or five cakes of cottage cheese on one of the shelves in the refrigerator, one of which I am sending you along with the butter. This was made over a year ago and has gone so bad that the mold even penetrated the parchment paper in which it was wrapped. I have, of course, ordered that cleaned up and the place thoroughly disinfected.

"I am wondering whether there is any connection between this and the growth in the butter. On the other hand, if we can trace back the growth in the butter to perhaps one or two of the creamery patrons, I may be able to find the cause of the butter going rancid so rapidly. I am anxious to see the trouble straightened out, if possible, because the creamery will not long exist if the trouble continues to break out at frequent intervals."

In February, 1915, we sent a form letter to all of the creameries of the state asking for information concerning this trouble. The replies received showed that many were unacquainted with it, partly because they did not make unsalted butter, but four or five reported more or less trouble of this kind. Later in the year Mr. Stoddard made an examination of two or three creameries to determine, if possible, conditions favoring its development. Separation cultures were made by Mr. Stoddard from several of the samples received at different times, and the following fungi were obtained:

(1) *Mucor,* sp. undet. (2) *Alternaria,* sp. undet. (3) *Penicillium roqueforti,* according to Thom. (4) *Oidium lactis,* a common fungus of milk and its products. (5) *Epicoccum,* probably *E. purpurascens.* The *Epicoccum* at first was mixed with the *Oidium* in our cultures and did not form spores. We thought it might be an *Oidium* or *Oospora.* Later Mr. Stoddard got it in pure cultures producing the characteristic spores of several cells united into a globular, semi-sessile ball. This last fungus is the one that was responsible for the red colonies in the butter. The *Penicillium* was responsible for blue-green and the *Alternaria* and *Mucor* for blackish growths.

Some inoculations on good unsalted butter were tried but were not very successful, in most cases developing best when the fungus worked down between the tubes and the butter where there was little air space and more moisture. There seemed to be some indication, too, that certain species followed in the wake of the others. However our tests were not extensive enough to be very trustworthy. If the inoculations had been made on butter covered with paper better results might have been obtained.

Concerning the development of the trouble in the creameries, etc., the following information was obtained. The molds were confined to unsalted butter, the salt evidently acting as a preservative. Some claimed that where the butter was wrapped in paper dipped in hot brine they were not so likely to develop. Others claimed that when the milk was pasteurized there was no trouble. Undoubtedly in some cases the trouble was due to unsanitary conditions in the dairy itself, as in the case cited by Prof. Judkins. Care in handling the butter after it was made, especially as regards moisture, cold storage and length of time the butter was kept, also entered into the problem.

Another quite important factor was the condition of the milk when it arrived at the creamery. Most of the fungi isolated were common saprophytic species that easily develop in cattle barns on moist hay, bedding, silage, etc. Petrie dish exposures by Mr. Stoddard in two barns developed very similar species to those recorded here. The *Epicoccum* was thus obtained both in barns and in one of the creameries where this trouble developed. The cleanliness of the barn, the care used in milking and keeping the air free from dust at that time and the protection given the milk before delivery, all are factors determining the number of spores that will fall into the milk and cause trouble later.

While unsalted butter is still used to a considerable extent by Jewish families and some of the larger hotels and restaurants. the reason no complaints have been made in recent years is probably because most of the creameries of the state have gone out of business. Their decline was due to their inability to compete with milk sold for direct family use and to the destructive competition of the large milk corporations that now dominate the market.

There are comparatively few references, so far as we have found in botanical literature, concerning molds that cause trouble in butter. We are indebted to F. C. Stewart for calling our attention to several of the following:

European investigators have done the most work along this line. Lafar and his co-editors (Handb. Techn. Myk. 1907 ed.) give resumés of most of this work together with references to the literature. In vol. 2, p. 214, *Cladosporium butyri,* a fat-splitting fungus, is mentioned, especially in connection with *Oidium lactis,* as a cause of rancid butter; while, pp. 220-1, bacteria are mentioned as causing red and blue specks in butter, nothing is said about fungi causing similar color troubles. In vol. 4, p. 525, *Mucor Mucedo* and *M. racemosus* are also mentioned as fat-splitting fungi found in butter.

Gripenberg (Milch. Zeitung 28: 626-8, 644-6, 662-3. 1899.) published quite an extensive article dealing with experiments under which infection of butter takes place. He found infection comes from the wood of the tubs, the paper wrappings and the air. The chief fungi responsible are *Mucor, Penicillium,* and *Trichosporium.* Hard wood tubs, thick paper, absolute cleanliness, soaking tubs and paper in concentrated salt solutions (over 25%) or steaming paper and tubs are preventive measures recommended.

According to Stewart, Happich (Zeitschr. Fleisch- Milchhygiene 11: 297.) found *Botrytis, Oidium lactis, Penicillium* and *Mucor* in moldy butter. Hanus and Stocky (Zeitschr. Unters. Nahr. Genussm. 3: 606. 1900.) report *Mucor Mucedo* to be a fat-splitting agent in butter.

We found no definite references in European literature to red spots in butter caused by a fungus, though according to Saccardo, (Syll. Fung. 4: 20. 1886.), Trabut reports *Oospora ruberrima,* originally described by Saccardo on damp wax of wasps, as occurring on butter in Algiers. The spore masses of this fungus are red.

In America, while considerable work has been published on the bacteria of milk and its products, but little along the same line has made its appearance concerning fungi, except that on cheese by Thom and others. However we have found a few references to moldy butter, chiefly relating to control methods.

Apparently not so much trouble is experienced now as formerly because of this advanced knowledge of control methods.

Duggar (N. Y. Prod. Rev. Amer. Creamery. Oct. 27, 1897.) in a popular article was one of the first, at least among botanists, to suggest preventive measures for controlling molds of tub and paper-wrapped butter. He found tubs made of sap wood most objectionable, spreading from this through the paper into the butter. He advised steaming the tubs and keeping them dry; also treatment of paper and tubs with copper sulphate.

Rogers (Exp. Sta. Rec. 14: 534. 1903.) is reported as isolating a fat-splitting torula yeast from several samples of canned butter. Its action was weaker than that of fat-splitting molds. The same author (U. S. Dep. Agr. Bur. Anim. Ind. Bull. 89: 7-13. 1906. *Ibid.* Circ. 130: 1908.) described methods of "Preventing Molds in Butter Tubs" and "Paraffining Butter Tubs" in the publications here cited and especially recommended the paraffining of tubs giving directions and details.

About the only article dealing with the fungi causing these troubles is that by Thom and Shaw (Journ. Agr. Res. 3: 301-10. 1915.) on "Moldiness in Butter." They classify the fungi found under the following headings: (1) Smudged or *Alternaria* type, including here besides the *Alternaria, Cladosporium butyri, Stemphylium butyri* Patt., *Cladosporium* sp., and our red fungus, an undetermined specimen of which was sent them. (2) Green-mold type, including *Penicillium roqueforti, P. expansum, P. chrysogenum,* etc. (3) Oidium type, producing various shades of orange-yellow by *O. lactis.* Besides these fungi they noted under certain conditions the presence of *Mucor* sps.

INJURIES AND DISEASES OF PLANTS ARRANGED ACCORDING TO HOSTS.

Apple, *Pyrus Malus.*

Bacterial Fruit Spot, Bacteria undet. Plate XXXIV, b. Early in October, 1919, several diseased apples were received for examination from Mr. E. M. Ives of Meriden. Two of these presented an appearance, in certain areas, a little different from anything that we had seen before; in fact, on superficial examination, these areas looked as if they might be due to spray or sun scorch of an unusual type. An examination of the injured tissue, however, revealed the presence of such numbers of

bacteria as to lead us to the conclusion that these were, if not the primary, at least the secondary cause of the trouble. The skin over these extended irregular areas was slightly sunken and reddish-brown in color, in strong contrast with the normal reddish skin. The parenchyma cells immediately beneath the diseased areas were also reddish-brown, as compared to the normal white tissue, and were somewhat collapsed with contents dead. The bacteria were especially abundant in the intercellular spaces. While the apple showed injury by the railroad worms, these had no apparent relation to the bacteria since their channels were not connected with this injury. The photograph reproduced here gives a somewhat unsatisfactory view of the trouble because of the high lights shown, but the principal diseased area is in the center from which a strip of the skin has been removed.

Cultures were attempted by taking tissue from the interior diseased parenchyma and placing it in test tubes of agar. Practically all of these produced bacteria but they were not pure, showing in some cases yellowish and in others whitish growths in the different tubes. The latter seemed the most likely to contain the injurious species but cultures made directly from these colonies, without attempts to isolate a single form, also showed that they were impure. Further work at this time being neglected, the cultures were left until too late to properly isolate and identify the organism. While these bacteria might have been an accidental invasion following some previous injury, it is also possible they were the pear blight organism on an unusual part of the host, since this organism occurred in these orchards especially on pears, and the owner kept bees. However, we have seen no references in literature where this blight occurred on mature fruit after the manner described here.

Bark Canker, *Myxosporium corticolum* Edg. This fungus while not reported before is evidently not a new or uncommon one in this state. It does not seem to be a very vigorous parasite as it is often associated with winter injury of the bark or wood. When so associated it looks much like the black rot canker, *Sphaeropsis malorum,* with which it is often confused; especially as the two are sometimes found in the same collection or even together on the same branch. The bark canker seems to penetrate less deeply, being confined to the bark which may

slough off and a new growth free of the fungus develop beneath. The fruiting pustules of the two are also similar, but, if the spores are oozing out, the white tendrils of the bark canker usually distinguish it from the black rot canker whose spores are deeply colored. However, when young the black rot spores are also hyaline and about the same size (perhaps average wider) and shape, so they may be mistaken for each other. In fact on the winter injured specimens mentioned in our Report for 1906, p. 310, both these fungi are present according to our recent examinations, although originally we reported only the black rot. The bark canker was called especially to our attention in the spring of 1919 by specimens from Danbury, which contained both this and to a less extent the black rot fungus; it was also found a short time later prominent on a small winter injured tree at East Haven.

Paddock (N. Y. Agr. Exp. Sta. Bull. 163: 203. 1899. *Ibid.* 185: 211. 1900.) and Stewart *et al.* (*Ibid.* 191: 298. 1900.) were the first to make early mention of this fungus which they called *Macrophoma malorum.* More recently Edgerton (Ann. Mycol. 6: 48. 1908.) has shown that this name is a synonym of the black rot fungus and he has described the bark canker as a new species and given it the scientific name used here. Paddock's inoculation experiments with the fungus failed to show its parasitic nature; so it is not likely to prove a serious pest at best.

Downy Mildew Rot, *Phytophthora cactorum* (Cohn & Leb.) Schroet. In late August, 1918, the writer received a dozen dried apples from J. S. Adam of Canaan, Conn., which had been stored in paper bags since the previous fall. These apparently had not rotted but dried down into the preserved specimens much like raisins. They were so full of sugar that Mr. Adam wanted to know if this was an unusual occurrence. Upon examining the reddish preserved tissues microscopically, we were much surprised to find an abundance of a non-septate guttulate mycelium, of variable diameter, much like that of *Phytophthora.* Cultures attempted from this tissue failed, however, to produce any growth so the mycelium was evidently dead at this time. The next year stored pears sent from Bridgeport showed the same type of non-fruiting mycelium present; in this case we were able

to isolate the fungus, produce its fruiting stage in cultures, and so accurately establish its identity as above named. A more complete statement concerning the fungus is given in this paper under Pear, *q. v.*

HEART ROTS, *Polyporus admirabilis* Pk. and *P.* (*Spongipellis*) *galactinus* Berk. Dodge (Myc. 8: 5-14. Ja. 1916.) in his article entitled "Fungi Producing Heart-Rot of Apple Trees" describes these two species as partly responsible for this trouble. The former occurs singly, or more frequently in calla-lily-like clusters, on the trunks showing as large milk-white, centrally depressed, fragile, fleshy fungi that on drying become hard and leathery and have a peculiar "glacé kid glove" feel to the upper surface. His observations on the species were made chiefly in Litchfield Co., Conn. He collected specimens at the Columbia Camp and vicinity near Litchfield, but he reports other specimens from Redding. In May, 1918, the writer also collected an old specimen of this species on a dead apple tree at Union, Conn.

The second species, *P. galactinus,* is smaller but in its bracketed group becomes even more conspicuous and is of about the same color. Dodge reports this from the same two localities as the other species. Recently Murrill (Myc. 11: 310. 1919.) also noticed it on apple trees in Eastern Connecticut, and the writer collected it on a living apple tree at Norfolk in 1916. Others have also reported it from Connecticut. Both of these fungi, while causing a rot of the heart wood, do not seem to especially attack the living tissue and so cause much less damage than if that were the case.

WHITE HEART ROT, *Fomes igniarius* (L.) Gill. We have seen this fungus several times in this state upon living apple trees. The oldest specimen we have in the herbarium is from Norfolk, collected in September, 1911, and it was found there again in 1916. It was also collected twice from an apple tree at Milford, the latter year. It is treated more fully under Oak, *q. v.*

Hail Injury. In one of our spray bulletins, which see (Conn. Agr. Exp. Sta. Rep. 1911: 382. 1912.), we briefly mentioned and showed a half tone of hail injury to the apples at our Mt. Carmel farm. Hail storms coming on the young fruit produce in time some misshapening of the mature fruit but

especially show their effect as conspicuous russeted or corky spots on the skin. In 1918 we heard of more or less injury at Wallingford to the fruit but had particularly called to our attention hail injury to the twigs in the Bellinger orchard at Litchfield. Mr. Stoddard, who examined the orchard to obtain data, found that it appeared on the 1 to 3 year old twigs on a certain side of the trees and the owner recalled a severe hail storm of the previous year that came from that direction. The beating of the hail had so bruised the bark that a callous growth was formed beneath, causing the bark to split open and reveal the slight swelling.

Malformed Twigs and Aerial Crown Gall, *Pseudomonas tumefaciens* (Sm. & Town.) Stev. Plates XXXV, a-b. Besides the hail injury mentioned above, we have received at various times for identification peculiar malformations of apple twigs, as to the cause of which we were not always sure. Two of these are shown in the illustrations given here. The one that is shown in Fig. a, we have usually called aerial crown gall. The ordinary nursery type of galls at the base of stems and the hairy root, we have mentioned in our Report for 1903, but the specimens considered here have been studied without a chance to examine the trees in the orchard and thereby determine the condition of their roots. These aerial galls occur on both young and old trees. Hedgecock (U. S. Bur. Pl. Ind. Bull. 186: 15. 1910.) pictures (Plate V, Fig. 1) and describes this form and associates it with the hairy root type of crown gall. Garman (Ky. Agr. Exp. Sta. Bull. 93: 106. 1901.) previously pictured and described a similar trouble as a "Knot Disease," and while he thought it contagious he did not associate it with the crown gall which he described in the same bulletin.

This trouble is usually found by the apple growers in late winter when pruning the trees and the specimens sent us show as a distinct lateral growth on the branch or as a swelling at the base of a side branch. Occasionally it takes the form of a distinct spherical knob like the typical basal crown gall. More frequently it forms flattened growths, at first perhaps smooth or with smaller knobs on it but usually with an abundance of small closely packed protuberances something like adventitious buds. These affected tissues die prematurely so that we have

never seen these "buds" develop further. Some of these areas on larger branches reach a lateral diameter of two inches, or where abundant, individuals may partly coalesce into even larger areas, but they rarely grow out half an inch beyond the surface of the bark. While we have never heard of these growths killing the whole tree, where extending completely around the branches as they sometimes do, they killed these in time.

The specimens preserved in the Station's herbarium and letters show data as follows: (1) W. T. Coe & Son, Durham, Apr., 1907, branches ½ to 1½ inches diameter, in center of tree, with numerous irregular swellings with abundance of "buds" on these. (2) J. O. Landon, Norwich, Mar., 1911, rounded smooth typical gall on ¾ inch branch showing winter injury of heart wood. Reported several galls on a single 12-15 year old tree. (3) E. S. Lovell, Newton, Apr., 1913, several irregular and roughened swellings, largest about 1 inch diameter, around twigs about half their size. Three Sour Bough trees infected. (4) F. P. Tolles, Terryville, Apr., 1915, branches 2 inches diameter with large flattened areas with abundance of "buds." (5) C. E. Shepard, Mt. Carmel, Apr., 1917, branches on young tree, shown in photograph. (6) H. J. Tillson, County Agent, found in orchard near Norwich, Mar., 1917, same type as Lovell specimens; one tree badly infected.

The other type of abnormal growth has been sent less frequently for identification, and we are even less certain of its origin. The specimens, illustrated in Fig. f, were received in March, 1913, from J. T. Cullen, Derby. These show young twigs with an evident swelling below a terminal bud or branch that has been killed and a new branch developed from a lateral bud. The swelling is largely due to an abnormal development of spongy parenchyma which at least in some cases dies prematurely. One could easily imagine such a growth due to winter injury of the terminal branch or bud, to insect stings or mechanical injury in some way. Quite frequently one sees in orchards, especially on certain varieties, as Ben Davis, very similar natural swellings apparently due to abundance of food material stored in the tip of the year's growth that retains the swelling somewhat the next year at the base of that year's growth. No injury to the tissues follows in these cases. There are

cases where such malformations as described here are claimed to be the result of the crown gall bacteria. Hedgecock (*loc. cit.*, Plate IV, figs. 1-2) shows by his illustrations and his statement that they are the "early stage of the aerial form of the 'Hairy Root'" and finally develop into the type of trouble first mentioned in this article.

A very similar trouble to this on pear twigs we have described elsewhere in this Report as due to winter injury. Because of our uncertainty that the crown gall germ is always responsible for these two injuries they are described here both as physiological and bacterial troubles.

Mice Girdle. Each year, during the winter season, mice cause more or less injury to trees by eating off the bark at their base. Some years, however, the injury is much more serious than in others, and when there is an abundance of snow on the ground the injury seems to be worse. Apple trees suffer more than any others though complaints have been made of injury to peach, maple, Scotch and white pine. The winter of 1919-20, with its abundant snowfall, apparently was the worst of any yet noticed. Even poison ivy was girdled along fence rows. In a nursery we saw considerable injury to Japanese maples and other ornamental plants. Reports were received of serious injury in many apple orchards, and to a less extent in peach orchards, to both young and old trees so that many thousands of fruit trees in the state were thus girdled. Most of this injury occurred below the snow line. We will not discuss the trouble further here, but refer the reader to the special article on this subject by Mr. Stoddard recently issued by the Station (Bull. of Inf. 10: 1-7. *Figs. 1-8.* Mr. 1920.).

Smoke Injury. In July, 1919, a letter was received by the Station from C. A. Burley of Stamford in which he wrote: "I have an orchard which (I think) is being killed by smoke from a factory alongside of it. In fact several of the trees are already dead and the others very weak. I would like very much if you could send someone to look over the situation." Soon afterward the writer and the state forester, Mr. Filley, went to Stamford, and with Mr. F. A. Bartlett and one of the parties interested examined the orchard and the vicinity for the cause of the trouble.

A suspicious thing, in the mind of the writer at least, was the presence, about in a direct line a quarter of a mile away but lower down near a stream, of a chlorine factory that was used during the war by the government for making chlorine gas but now abandoned. An examination of the vegetation, especially the trees immediately around this factory, showed no injury except to a few trees on the edge of the stream into which had been emptied considerable chemical refuse from the factory. In other words as there seemed to be no indication here of injury to the trees or herbaceous vegetation from possible escaping fumes, there was no likelihood of the trouble in the orchard being due to such a cause.

The orchard, however, bordered directly on one side of the buildings of a bronze factory, through the open windows of which were blown the minute particles from the burnished bronze. More or less of this dust settled upon the surrounding vegetation and could be distinctly seen as minute golden particles on the apple leaves even some distance away. The man who showed us around thought that the bronze dust was responsible for the injury to the trees. At first sight this also seems plausible, as the apple leaves where the dust was most abundant had numerous small reddish specks often immediately under the bronze particles. An examination of the vegetation immediately under the factory windows where the dust was thickest, showed no evident injury on such tender leaves as pokeweed, burdock, *Bidens,* etc. It seemed probable, therefore, that this dust caused no harm, unless possibly on long standing some unknown chemical change took place that produced these specks and even then this would not account for the death of the trees and the severe scorching of the foliage elsewhere. The smoke from the factory was carried off by a high stack, with the wind mostly taking it away from the trees, thus eliminating this as a factor. In the rear of the factory, was a temporary incinerator with a low stack for burning rubbish including the waste that was used in burnishing the bronze. The smoke from this was strong and could be easily carried, with the wind in the right direction, over the apple trees. In fact it was in an extension of the orchard nearest this that most of the dead trees occurred. From what we have seen of smoke injury elsewhere, this seemed to us to be

the most logical source of the injury. Just what chemical matter was included in this waste that could cause the injury we did not determine, but if sulphur was present it could have been responsible.

Winter Injury Cankers. The severe winter of 1917-1918 did great harm to various trees in this state, especially to cultivated ones and particularly to peaches and apples. We have in previous Station Reports discussed various forms of winter injury to the apple, and in the Rept. of the Conn. Pom. Soc., vol. 21, p. 102, 1919, have given a brief resumé of these including the trouble mentioned here. We wish in this note merely to mention this unusual form of winter cankers not noted before in our Station Reports. One of the worst injured orchards that we saw was that of W. B. Johnston, of South Meriden, who had us examine it in June as he thought he had some unusual disease.

The orchard, chiefly Baldwins, was on an exposed hill that got a full sweep of the winter winds and had shown no such injury the previous season. Trees that bore heavily the previous fall were those that suffered the most winter injury. Besides the dead and badly injured trees, there were some that showed irregular dead areas on the trunk or elongated dead areas on the limbs that looked like disease cankers as they were sharply marked off by cracks in the bark from the living tissues. Often these showed fruiting pustules, thus increasing the impression of their fungous origin to one not acquainted with the facts of the case. A peculiarity of the cankers in many cases was their situation *on the lower side of branches* with the upper side healthy or only slightly injured! Just what caused this difference in susceptibility to injury we do not know. Possibly the tissues of the upper side were more matured or contained less water. Such cankers on the under side of branches were not infrequent in other orchards following this severe winter.

Ash, White, *Fraxinus americana.*

ANTHRACNOSE, *Gloeosporium aridum* Ell. & Holw. We have reported anthracnoses before on maple, oak and some other trees, but in the summer of 1919 we received for the first time specimens on white ash. They were sent, early in June, both by Miss Jessie H. Brown from Lyme and H. O. Taylor from

Cobalt, who complained of the trouble as a serious one causing more or less defoliation of their shade trees. In the first case at least, the leaves were also attacked by the rust mentioned below. The disease appeared on the leaves as they were reaching maturity causing a scorch-like burn usually involving considerable area from the margin inward; occasionally there were smaller isolated spots within. The diseased area was somewhat translucent, of a light or yellowish-brown color, sharply marked off from the healthy tissues and easily broken when dry. The very inconspicuous fruiting pustules were seen with a hand lens more or less abundantly imbedded in the lower surface. The wet spring weather was very favorable for this as well as other true anthracnoses.

Four different species of anthracnose have been reported on this host and at least one or two on other species of ash. So far as we can determine from the printed description, our specimens agree best with the species given above which was published by Ellis and Everhart in the Journ. Myc., p. 21, 1887. The specimens upon which this species was based were received from J. J. Davis of Racine, Wis. Davis (Trans. Wisc. Acad. Sci. Arts 9: 169.) in 1892 erroneously gave the authority for the name as E. & E. He writes, "Abundant. When developing vigorously on exposed trees it attacks one edge of the leaf, causing it to curl toward the affected side. When less vigorous on leaves of shaded trees it occurs on roundish spots about 5 mm. in diameter."

The spores as we find them are hyaline, oblong or broadly oblong, slightly pointed at the ends, straight or very slightly curved, 6-10μ by 2.5 - 3.5μ but chiefly 7-9μ by 3μ. *Gloeosporium irregulare* Peck, described shortly after this species, does not seem to differ materially from it except in the greater width of the spores (4-5μ) as given by Peck. Recently we have received typical specimens of *G. aridum* from Davis, and of *G. irregulare* from House, and both express the opinion that they are the same species. Our examination of these specimens also confirmed our suspicions that this was the case. Dr. House writes, "I think there is no question as to the identity of *irregulare* with *aridum*, apparent differences in the measurements given in the description are not borne out in the specimens. I enclose a bit of the type."

RUST, *Aecidium Fraxini* Schw. Plate XXXV, c. We have illustrated and briefly described this rust in previous Reports (Conn. Agr. Exp. Sta. Rep. 1903: 304. *Ibid.* 1911-12: 343.) as occurring not uncommonly on the blades and petioles of the white ash in this state. During the early summer of 1919 it was more abundant than we have ever seen it before. It was sent in several times as causing more or less injury to the lawn trees and was said to cause severe defoliation in one case. In our collection this year we found the rust not only on the blades and petioles but also on the young stems of this year's growth, the maturing winged seeds and the staminate blossoms which had been curiously transformed through the action of the phytoptus mite occurring on this host. The mycelium causes more or less distortion of the infected parts and this is especially so on the branches, where it produces gall-like growths, covered with the aecial stage, and often involving the young axial parts, as shown in the illustration. When young the aecia are elongated but wear away in time to short cups. Farlow (Proc. Soc. Prom. Agr. Sci. 9: 26. 1888.) reported a serious and extended outbreak of this fungus in 1885. Arthur (Bot. Gaz. 29: 275.) reports cultures made in 1899, and several times since, with the III stage of a *Puccinia* from *Spartina* sps.; he produced the I stage on *Fraxinus lanceolata.* He calls the fungus, therefore, *Puccinia fraxinata* (Schw.) Arth. So far as we have found, no one has infected other species of *Fraxinus* with the *Spartina* rust. Arthur however failed in several attempts with other genera in the same family as *Fraxinus.* While this rust is common along the Sound where *Spartina* also occurs, we have often seen ash trees badly affected quite removed from any specimens of it. Our efforts, however, to obtain any further clues of relationship met with failure. We tried several times to inoculate species of *Agropyron repens, Poa pratensis, Spartina* (large and small) sps., and even leaves of *Fraxinus americana,* with the I spores from the last host without result.

Asparagus, *Asparagus officinalis.*

ANTHRACNOSE, *Colletotrichum* sp. On Burr's Mammoth Asparagus at the Station farm, the latter part of September, 1919, we noticed a conspicuous disease on the green stems that

we had not seen before. This was causing more or less injury to the infected plants. Irregular, often elongated, grey areas, of greater or less extent, appeared in the normal green skin; in these were numerous very small but conspicuous, black fruiting pustules. The center of these often showed a white spot evidently where the spores were discharged. The spores are hyaline, narrowly to broadly oblong, often somewhat pointed at one end and 12-17μ long by 4-6μ wide. The fungus is evidently that briefly described and pictured by Halstead (N. J. Agr. Exp. Sta. Rep. 1896: 410.) in 1897 but of which he gives no description of the spores, etc. There are no setae on the fruiting pustules of our specimens so that the fungus looks as much like a *Phoma* as a *Colletotrichum*. Several species of each of these genera have been described on asparagus, but all appear to be on the dead stems and none quite like ours. We have found no further reference to Halstead's *Colletotrichum* sp., and Cook writes that there are no specimens of it in the herbarium at New Brunswick. On our specimens, often in the same spots, there is also a *Fusarium,* previously mentioned by us (Rep. 1903: 305.). This probably has no connection with the *Colletotrichum* and seems to form more definite elliptical or elongated spots with a distinct purplish border, but it is difficult to tell, in some cases, which fungus caused the spots. It may be that both are languishing parasites on the older stems or that one follows the other as a lesser parasite.

Fasciation. Harshberger in his book (Mycol. Plant Path.: 329.) describes fasciation as follows: "Fasciation in its simplest form consists of a flat, ribbon-like expansion of stem, branch, flower clusters, flowers and fruits which may be cylindric below, but flattened above." Sorauer (Handb. Pflanzenkr. 1: 332.) says concerning these fasciations: "We may likewise consider as due to local over-nutrition, the condition arising when a cylindrical branch becomes broad and flattened. It then looks as if a number of branches had grown together; nevertheless, this is only rarely the case, for almost always only a single branch is involved, which, by broadening its vegetative point, no longer has a vegetation cone at its apex but a comb-like vegetative surface." The last writer also states: "We have seen already in roots held fast between split rocks that pressure from two

opposite sides may give the axis a band-like form. Under certain circumstances such a changed direction or growth may continue if the cause of arrestment itself has disappeared." Cowles (Text Book Bot. 2:786.) writes: "The phenomenon is not well understood, but often it is believed to be associated with 'over nutrition'; sometimes it is produced by mechanical causes, or by insect or fungal activities (as in *Œnothera*). Fasciation sometimes appears to be inheritable, but this remains to be established, at least as a general proposition."

Mr. Frank Hanchett of Falls Village, Conn., brought to the Experiment Station during the winter of 1918 a specimen of asparagus (partly shown in Plate XXXVI, a, here) taken from his garden the summer previous, that showed evident fasciation. The stem was flattened so that when green it was two and a half inches wide across the base as against half an inch in thickness. The stem as brought to us was about two feet long and was flattened the entire length. The apex was narrowed and twisted into an irregular spiral coil of two and a half turns. About half way down, the specimen branched but the second branch was broken off a short distance above its origin so the nature of its apex was not disclosed. Sections made through the stem showed abundance of the mycelium of some fungus scattered somewhat irregularly through its length. These threads were much more abundant in spots, evidently developing best in the vicinity of the fibro-vascular bundles, especially in the pith cells surrounding them and in the vascular ducts. Concerning the identity of the fungus we could not be sure because no definite spores were seen, but it appeared to be a *Fusarium*. There may have been some connection between the presence of the fungus and the fasciation, but we cannot be sure.

Keeping this malformation in mind we unearthed several examples of fasciation of asparagus during the spring of 1918. These came from Milford, North Haven and Middlebury, so this trouble cannot be considered very rare. We did not find in these subsequent specimens the mycelium of any fungus though all were not carefully examined. The largest of the two or three specimens from the Whittemore estate at Middlebury was about 3 feet long and showed short bifurcated and slightly coiled tips. The specimen from the Clark Wilcox place at Milford

was by far the most striking, being at least five feet long and the flattened side of the stem three inches wide, with numerous branches scattered along its sides in the axils of the scale-like leaves, as was the case with the other specimens. The stem was coiled in one complete turn near the center but the nature of the tip was obscured though probably slightly bifurcated.

In 1919 market agent Stack brought us a specimen purchased in the New Haven market, and in 1920 other specimens were found in the Station's asparagus bed. Efforts in 1920 to produce this flattening by various artificial methods involving pressure on the growing tips were apparently not successful; but further work along this line will be done.

Besides these fasciations of asparagus, we briefly describe in this Report somewhat similar troubles on Larkspur, Pea Shrub, Rose and Sumac, and previously (Rep. 1913: 6. 1914.) we have described and figured the same thing on a young apple twig. Besides the flattening of the stem, common characters with most of these fasciations are the bifurcation and coiling of the tips.

Bean, *Phaseolus vulgaris.*

Bacterial Wilt, *Bacteria* sp. Plate XXXVI, c. Several times in the early summer of 1918, we had complaints of young beans in war gardens dying from a scorch-like wilt. We did not have opportunity to thoroughly investigate all of these complaints, but such plants as we did examine led us to conclude that the trouble was not primarily a sun-scorch but resulted from invasion of the vascular system by bacteria. These eventually more or less completely cut off the water supply, with resulting wilting and scorching of the leaves under exposure to bright sunlight. The spring and early summer had been unusually wet and so favored bacterial invasion of the stem through injuries of the roots. Some of the specimens examined showed as yet little wilting of the foliage but evident invasion of the vascular ducts both in the stems and the leaves. Often the invaded tissues were apparently little injured; occasionally bacteria were found in the pith of the stem as well as in the ducts. A peculiar case shown us by F. J. Reveley, supervisor of war gardens at East Haven, was in a garden of eight rows of beans, four of which had the trouble badly, while the other four were

apparently free. Some bacteria, however, were found in the plants of the unaffected rows. The only difference, so far as we could determine, between the affected and unaffected was that the latter had a little more shade!

While there is a bacterial disease causing a spotting of the leaves of beans, the trouble mentioned seems to be another thing altogether. It is more like the bacterial wilt of cucurbits, but whether, as in that case, caused by a definite organism we do not know. We have seen no references describing such a trouble of beans.

Beech, *Fagus* sps.

Gas Injury. Through the kindness of Mr. G. F. Herthal, tree expert, the writer, with the State Forester, was shown in August, 1919, a couple of beech trees on the Nathaniel Wheeler Estate at Bridgeport, that developed the unusual injuries mentioned here. The first tree was near a driveway under which passed the gas supply to the house. The tree for at least the past two years had developed a serious injury of the leaves soon after they matured. This showed as a scorch, chiefly at the margins, and caused more or less defoliation. Otherwise the tree looked healthy and there was no apparent fungous or insect cause for the trouble. As the scorch had a similar appearance to gas injury that we have seen on maple trees on the streets, we finally concluded that there was a slight leak from the gas pipe in the road that caused injury to the roots and thereby affected the leaves.

Lightning Injury. In this same yard there was a very old and noble copper beech which a number of years before had been struck by lightning. The most evident effect was the killing of the bark at the base of the tree so that at this time it was entirely girdled, except for a slight connection on one side with a large root. While the tree had been trimmed of a large dead branch in the past and had one nearly dead main branch on one side, it still maintained evident vigor of the main very large branches despite this almost complete girdling at the base.

Bitter Sweet, *Celastrus scandens.*

Chlorosis. This was merely a case of yellowish-white spotting of the leaves, most frequently near the margin. Some leaves had yellowish areas instead of the small definite spots. This

trouble may have resulted from some insect sucking the juices from the leaves when they were quite young, but it was more likely due to the late frosts that came early in May, as we have seen somewhat similar injury caused on other plants. See Frost Injury under Tobacco. The specimens were found in June, 1919, on a wild plant at East Haven, but may be looked for on cultivated ones, as some of the cultivated species have variegated foliage.

Blackberry, *Rubus* sps.

ORANGE RUST, *Caeoma nitens* Schw. Germination tests so far made show that this rust on cultivated *Rubus villosus* (Gray's 6th ed.) in this state belongs to the short cycled form. This rust was found doing serious damage to a certain variety in a plantation in Westville in 1919. On the wild blackberries, likewise, all germination tests of the collections show the rust to be this form, except one which was long cycled, and later collections disclosed the III stage of *Gymnoconia interstitialis* on this same plant. See "Raspberry" for further details.

Box, *Buxus sempervirens* var. *suffruticosa*.

Winter Injury. From time to time during the past years, there have been sent to the Station branches of box in which the leaves were dead, having a yellowish-white color, and complaint was made that the whole plant or part of it was in this condition. Search has sometimes revealed immature stages of some fungus developing in these dead leaves or branches, but no definite indication has ever been found that such a trouble was due to the attack of a particular parasite. Sometimes we have seen individual plants in the nursery showing this trouble, and we have wondered if it might not be the result of sun scorch.

After the severe winter of 1917-18, we saw so much trouble of this nature on box hedges that we could not but conclude that most, if not all, of these troubles trace back to severe winter injury of the leaves, stems or roots. We saw one hedge at the Whittemore estate at Middlebury in the spring of 1918, where the upper branches and leaves were all killed while those below were uninjured. In this case the hedge had been protected during the winter by an artificial covering but this did not reach the tops of the plants, with the result that the parts exposed were thus injured. Box is not entirely hardy so far north as this and

in severe winters some mulch protection, either artificial or snow, is usually needed to prevent winter injury. The winter of 1917-18 was so severe that many unprotected hedges were ruined. Why in some hedges certain plants are badly injured and others escape, we cannot surely say, but this may be due in part to the immaturity or the weaker condition of those affected.

Butternut, *Juglans cinerea.*

STAGHEAD, *Melanconium oblongum* Berk. We have not made personal observations on this fungus but have had it called to our attention by Dr. A. H. Graves who has made a study of it in this and adjacent states. He holds the view that it is largely responsible for the dead limbs so frequently seen on butternuts, and finally for the stag-headed appearance of the trees due to the death of the tops. A discussion of it by Dr. Graves appeared in Mycologia 11: 111-13, in May, 1919.

Cabbage, *Brassica oleracea.*

BLACK LEG, *Phoma lingam* (Tode) Desm. (*P. oleracea* Sacc.) Plate XXXVI, b. We have found this disease only twice in this state and then under conditions that were very unfavorable to the cabbage plants. It was first called to our attention about the middle of November, 1918, at the D. L. Clarke & Sons' farm at Milford. Cabbage plants had been set out very late in their field during dry weather. The plants used had been kept too long in the seed bed, and so were over-sized being long and spindling. They were dropped in a furrow, watered and then set in by tramping the earth around them with hoe and foot. The plants as a whole did very poorly, many died and others failed to make much of a growth, so that about 90% were failures. When seen by us the stem underground and partly above was badly withered, or decayed in many cases, as shown in the illustration. The fruiting pustules of the *Phoma* could be seen on most of the stems, but on others the fungus was not evident. The same fall at the Experiment Station farm at Mt. Carmel, we found a few freak plants in the club-root experiments that showed the same trouble.

The disease was first called prominently to the attention of cabbage growers in this country by Manns (Ohio Agr. Exp.

Sta. Bull. 228: 276-90.) of Ohio in 1911. It seems to be a trouble that starts in the seed bed but becomes most serious and conspicuous after transplanting in the field. The disease starts on the stem as a white sunken area, usually near the junction of a leaf petiole, eventually forms serious cankers or girdled areas, invaded by bacteria, etc., and becomes black in color, hence the common name of "black leg." The fruiting pustules are easily made out in the infected areas as small black dots. The spores are hyaline, oval to oblong and chiefly 3.5-5μ by 1.5μ-2μ. More recent investigations (Wisc. Agr. Exp. Sta. Res. Bull. 38: 6. 1915.) show that *Phoma oleracea* Sacc., as it is called by Manns, is a synonym of *Phoma lingam* (Tode) Desm.

Cabbage, Chinese, *Brassica pekinensis.*

Leaf Mold, *Alternaria Brassicae* var. *macrospora* Sacc. This fungus forms small, rounded, blackish, zoned spots on the leaves. We noted it, in 1916, from the Station's farm at Mt. Carmel, as "quite bad on some varieties." Apparently no specimens were saved so nothing further can be said of it.

Leaf Spot, *Cercosporella albo-maculans* (Ell. & Ev.) Sacc. This forms conspicuous greyish spots, with a more or less distinct border, that are from a quarter to half an inch in diameter. In dried specimens some of these spots retain a more greenish color than the rest of the leaf. Our specimens were collected on Aug. 30, 1917, at the Station's Mt. Carmel farm. So far as we have learned, the fungus has not been reported before on this host, at least under this name. We have had considerable trouble in identifying it because from the dried specimens it is quite difficult to determine how the spores are borne.

Alternately we have considered it under the genera *Cercospora, Cylindrosporium* and *Cercosporella,* since species on *Brassica* are described under each of these that fit our specimens fairly well, especially as regards the spots and appearance of the spores. *Cercospora brassicicola* P. Henn, described in 1905 from Japan on *Brassica sinensis,* however, seems not to be the same since the hyphae bearing the hyaline spores (40-80μ long) are said to be *dark colored* and 20-25μ long. We could find no such definite hyphae associated with the spores. If the author has mistaken other hyphae of saprophytic species that rarely occur on old spots,

we may have what he has described but we have no specimens for comparison.

Cylindrosporium Brassicae Faut. & Roum. (Rev. Myc. 13: 81. 1891.) seems to fit our specimens even better as the spores are said to be 80-120μ long (forma *Napi,* however, in Roum. Fungi sel. no. 6727, only 40-80μ) but they are enclosed *in the parenchyma.* Our study of these dried specimens (Roum. Fungi. sel. nos. 5679, 6727, 7318) leads us to believe that the writers were misled in their conclusions as to the origin of the spores and that they are really borne on the outside on short hyphae as in *Cercosporella.* Perhaps further study of fresh specimens from France is needed to definitely prove this point. This name antedates any of the others.

Cercosporella albo-maculans (E. & Ev.) Sacc., originally described as a *Cercospora* (*Cercosporella*) on *Brassica campestris* from California (Proc. Phil. Acad.: 378. 1894.) was placed definitely under *Cercosporella* by Saccardo (Syll. Fung. 11: 606.) because the hyphae (8-12μ by 2μ) bearing the spores were decribed as hyaline. The spores are given as 40-68μ by 2-2.5μ. Except for this somewhat smaller size of the spores the description agrees very well with our specimens. These latter we find to vary from 50-105μ (chiefly 65-90μ) by 2.5-3μ. They are hyaline, straight or somewhat curved and septate. The septa are more or less evident, usually three being found, but with staining even four to six can sometimes be made out. After much examination we definitely determined that the spores are borne externally on very short, inconspicuous, hyaline hyphae no wider than the spores. These may be somewhat grouped or isolated, and come from the stoma or directly through the epidermis. As the spores are easily broken the size given for them may vary according as one measures them whole or broken. We have seen a fragment of the type of *C. albo-maculans,* sent us from the N. Y. Bot. Garden, and found the spores to vary from 45-85μ by 2.5-3μ and as these measurements agree fairly well with those from our specimens we have adopted this name though we have small doubt as to their identity with the French specimens described under *Cylindrosporium.*

Soft Rot, *Bacillus carotovorus* Jones. Plate XXXVII, a. In the summer of 1918 a serious disease took off at least ten per cent

of the Chinese cabbage grown at the Station's Mt. Carmel farm. The outer leaves would wilt, drop over, turn yellowish and finally the whole plant would go down. An examination showed that the trouble was of bacterial origin and the dropping of the leaves was due to the rotting of the tissue at the base of the petiole and in the stem. When cut lengthwise through the stem, there was revealed a rotting mass that in time became hollowed out as shown in the photo. Sometimes the rot finally extended up the mid rib and even into the leaf blade. The wet season may have favored this trouble since the cabbage was grown on soil not in this crop before and very little manure was used; however, the rot was not very prevalent either the year before or after 1918, although 1919 was even more moist than 1918. The variety called Wong Bok seems to have been most subject to the rot.

While we made no special bacteriological study of the rot, it was so similar to the ordinary soft rot of cabbage and other vegetables previously recorded from this state, that we have little doubt that the usual soft rot organism was responsible for the trouble. Recently Brown and Harvey (Phytop. 10:81-90. Fe. 1920.) have described a similar bacterial rot of Chinese cabbage and have noted besides the rot a spotting of the leaves due to the same cause. They think, however, that, while the soft rot is due to different bacteria, the trouble really starts through invasion of the bundles by *Pseudomonas campestris,* the black rot organism of cabbage, etc.

Carrot, *Daucus Carota.*

Drop Rot, *Sclerotinia Libertiana* Fckl. Carrots bought from a grocery store by the writer in the winter of 1919-20 developed, on their outside, while stored in the paper bag, a rot with the conspicuous white mycelium and large black sclerotia of the above fungus. We have found the same fungus causing drop of lettuce and parsley in the greenhouse and dampening-off of seedling beets in hot beds (Rep. 1908:860, 863, 868.) A similar fungus of doubtful identity has been reported by us as causing a rot of stored cabbage (Rep. 1915:428.).

Celery, *Apium graveolens.*

Root Rot, *Pythium deBaryanum* Hesse. Mr. E. B. Hall of Middletown in September, 1915, sent us specimens of celery hav-

ing stunted roots more or less rotted off. An examination of these revealed the oospores of a *Pythium*-like fungus in the tissues. We did not determine the fungus more definitely at the time, but our recent study of a variety of similar troubles led us to re-examine the celery specimens and decide that the fungus was *Pythium deBaryanum.* In size and general appearance the oogonia and oospores are the same as those found in the Spinach trouble, *q. v.,* discussed elsewhere. In these old dry roots of celery, however, the oogonia have become thicker and wrinkled somewhat as shown in Plate LVI, 5. Very similar wrinkling however, is developed in the older artificial cultures of this *Pythium* when dried out, as shown in Plate LVI, 8.

Complaint was made of serious injury to the celery but whether or not this fungus was the chief cause could not be determined from the specimens received, as there was also a bacterial rot of the stems present, in some plants. In Aug., 1918, we had called to our attention a root rot of Golden Self-Blanching celery on the farm of W. G. Griswold at Wethersfield. This was so far advanced that the primary cause was not determined though *Fusarium* and bacteria were at least subsequent agents. A careful search for *Pythium,* however, was not made. It seems quite probable, however, that *Pythium deBaryanum* may often be the starting point of such root and stem rots.

Crinkle. Plate XXXVII, b. The illustration shows the contrast between a normal leaf and one with the crinkle. This trouble was called to the writer's attention, the last of August, 1918, by Mr. H. D. Peters of Highwood. He said the trouble appeared rather suddenly in his celery field and that the same seed had not shown it the year before. At the time of our examination the plants seemed to be outgrowing the trouble, as the newest leaves did not show it to any extent. Crinkle develops on the leaves as numerous small puckers or larger folds as if the lower surface had grown faster than the upper. Sometimes the segments of the crinkled leaves are much narrower than those of the normal leaves. Occasionally the color of the leaf is a lighter green but the general appearance is not like that of mosaic.

Evidently the trouble is developed in the young growing leaf and not after it is matured. No signs of lice were present and the folding was toward the upper surface rather than the lower,

the way lice normally injure the leaves. When the plants were set out early in July the weather was rather dry, they had not been watered, and their first leaves showed no crinkling. It seems probable since the central leaves showed the trouble most conspicuously that it was caused by a rather sudden change from the dry to the wet weather that followed with abnormally fast growth compared with that previously made, resulting in faster cell development on the lower side and the crinkling. In time the plants become acclimated to the change with a gradual return to the normal type of growth. Sanford White (see Plate XXXVII) was the variety that showed the trouble by far the most conspicuously though it was seen somewhat on Salzer's Early Bleaching.

Corn, *Zea Mays.*

ANTHRACNOSE, *Colletotrichum graminicolum* (Cesati) Wilson. The disease shows on the leaves of this host, at first, as small oval or elliptical spots containing more or less evident fruiting pustules. If numerous spots occur, the intervening tissues are soon killed so that elongated irregular, brownish areas run lengthwise of the leaf obscuring the smaller spots, and the tissue may become more generally invaded. The setae are prominent on the fruiting pustules and are blackish straight spines about 6 to 8μ wide at the base and 60 to 120μ long. The spores are hyaline, occasionally straight but chiefly decidedly curved and broadest near the center tapering to a decided point at the free end. They vary from 24-30μ by 5-6μ. We have found this fungus in this state twice, collecting it once in July, 1919, on leaves of Golden Bantam sweet corn at the Frank Beach farm in Woodmont. Here the fungus occurred as a parasite but did not seem to be causing any very conspicuous damage, being confined largely to the lower smaller leaves that sooner or later die anyway. The other collection, made on Aug. 24, 1918, was on the stalks of sweet corn from the same general neighborhood. The stalks had been collected for the Fusarium root rot mentioned later, and were kept for some time in paper bags where the *Colletotrichum* probably developed as a saprophyte.

This fungus was first presented in detail from this country by Selby and Manns (Ohio Agr. Exp. Sta. Bull. 203: 187-211. 1909.). Manns described it as a new species, *C. cereale,* and

found it was causing more or less injury to various cereals and grasses, being especially bad on wheat and rye, since it attacked the heads and caused withering of the grain. He found it on the leaves, heads, stems and roots of its different hosts, but he did not include corn among these. Later Wilson (Phytop. 4: 106-112. Ap. 1914.) made a special study of the nomenclature of the fungus and decided it was an old species that had received about a dozen specific names in the past and he adopted the one given here as the authentic name. He gives *Zea Mays* as a host, in fact the earliest collection in 1852 from Italy being in part on it. He also lists it on this host from Connecticut, New Jersey, S. Carolina and W. Virginia in the United States. The citation on *Zea Mays* from Conn., collected by Rorer, apparently is intended for *Sorghum vulgare,* since we have it in the Station's herbarium on this, and Wilson credits it to *Sorghum* only from this state in the main part of his paper.

We have not seen any reference in literature where the fungus was claimed to be an active parasite of corn, most of the collections apparently having been made on the dead stalks. While the size of the spores as found by us on corn are larger than those given by Manns, they are not larger than found by Wilson on some of the hosts and are similar in appearance and size to those found in the Rorer specimen on *Sorghum* (Conn. Rep. 1903: 358.). On this latter host, however, the spotting is much more conspicuous being very decided reddish-brown on the green leaves. It is commonly known as *Colletotrichum lineola* Cda. on this host.

Purple Fungus, *Monascus purpureus* Went. This fungus was isolated in Dec., 1916, from New Milford corn silage sent by L. W. Marsh who thought that the silage was causing the cattle fed on it to scour. Later he came to the conclusion that that was not the cause of the trouble. An examination of the silage showed many of the corn fragments of a decided reddish-purple color and on these by close examination a moldy growth of this fungus in fruiting condition was found.

The only reference we have found where this fungus was suspected of having caused injury is in Pammel's Manual of Poisonous Plants, p. 247, where he says: "The family *Monascaceae* contains one fungus which has been found in mouldy corn and silage in Iowa, the *Monascus purpureus* Went. * * * The

coloring matter from *M. purpureus,* known as 'ang-quac,' is used in Eastern Asia as a pigment, being produced by the growth of the fungus on rice. * * * Dr. Buchanan found this species in spoiled corn silage, which was responsible for the death of several horses in Iowa. This species possibly has been the cause of the disease, this fungus occurring only where air had access to the silage."

Concerning the coloring matter produced by the fungus Lafar (Tech. Myc. 2:10. Salter trans.) says: "To impart a red colour to rice wine, to various spirituous liquors, bread, cakes, and to the fish held in such high esteem (under the name of Macassar or red fish) in the Malay archipelago, the Chinese employ a colouring matter extracted from a red Hyphomyces, which they cultivate on boiled rice. The fungus grows with vigor on this medium, and imparts thereto a red coloration; and the dried cultures, to which a preservative addition of arsenic and mustard oil is made at the time of preparation, form an article of commerce under the name Ang-Khak. C. Went. has named this fungus *Monascus purpureus.*"

This commercial use would indicate that the fungus was at least not a very poisonous species and it is probably entirely harmless. Even when silage does produce illness in cattle the real cause of the trouble is quite an open question, indigestibility, bacteria and various fungi all coming in for consideration. Apparently as yet no organism has been isolated and fed directly, producing similar trouble, to prove its connection.

Root and Stalk Rot, *Gibberella Saubinetii* (Mont.) Sacc. In August, 1918, in company with Dr. Hoffer of the Indiana Station, we examined fields of sweet corn, grown for seed, in the towns of Orange and Milford, to determine if the *Fusarium* root and stalk rot, so serious in the sweet corn fields in Indiana, was present here. Connecticut supplies much of the seed of sweet corn grown for the canneries in the west. We found this trouble in small amounts in various fields of such varieties as Crosby, Evergreen, Howling Mob, Country Gentleman and Golden Bantam. It was only in a single field of the last variety, however, that the trouble was conspicuous enough to attract serious attention, as about 5% of the stalks here were injured. As shown to us by Dr. Hoffer, the trouble may start from the seed as a primary

infection, or it may possibly get into the young plant later through injuries of the roots. In time the roots are more or less rotted and the lower portion of the stalk invaded. By cutting stalks lengthwise from the base up, the infection is shown by the discolored and diseased tissues at the nodes for a shorter or longer distance according to the progress of the fungus upward. The lower leaves die prematurely and the stalk is often barren, especially in the west, and is easily blown or broken over. The trouble was seen again in 1919 on sweet corn, but as yet we have not looked for it on field corn where it probably also occurs.

While we have made no particular study of the cause of the disease we do not doubt that it is sometimes carried in the seeds, apparently through secondary infections according to Hoffer. However, we should judge, since it is not a very serious trouble here, that the infected soils of the west were more a source of infection there than Connecticut seed. We shall speak more of this matter, however, under "Poor Seed."

Hoffer, Johnson and Atanasoff (Journ. Agr. Res. 14: 611-12. 23S. 1918.) have recently proved the identity of the *Fusarium* of corn root rot in the west to the *Fusarium* causing scab of wheat, etc., which is so prominent in that region, and have connected these with a mature stage belonging to the genus *Gibberella.* This stage has also been found on old corn stalks recently in Connecticut fields. The ascospores of this are hyaline, four-celled, straight or slightly curved and chiefly 24-30μ long by 5-6μ wide. Ellis issued (N. A. F. no. 81, under the name of *Nectria* (*Gibbera*) *pulicaris* Fr.) what appears from our specimens to be a different thing on old corn stalks.

On one of our specimens we also found *Diplodia macrospora* Earle, fruiting abundantly. What connection, if any, this fungus may have with the root rot we do not know. *Diplodia Zeae* (Schw.) Lev. is reported as a serious disease of corn in Illinois (Ill. Agr. Sta. Bull. 133.) and Farlow and Seymour (Host Index: 156.) give it as a synonym of *Gibberella Saubinetii* Sacc.

Yearly rotation of corn, care being used not to follow wheat or rye, and the use only of healthy vigorous seed, are methods for limiting this trouble to minimum injury.

Root Rot, *Phytophthora cactorum* (Cohn & Leb.) Schroet.

There were various complaints in 1919 of corn not doing well, and the cause was not always evident from the information and specimens received. Some of the trouble may have been due to the *Fusarium* already mentioned, or to the leaf blight, *Helminthosporium turcicum,* which killed the leaves as if by a frost, especially in late planted sweet corn. In other cases apparently neither of these fungi was the responsible agent. An unusual case was called to our attention late in the fall by County Agent Southwick of Hartford who sent us corn stubble for examination and wrote as follows:—

"I got them from John Cannon who lives in North Granby. This particular field raised a good crop of corn last year but had no other fertilization this year than a thousand pounds, I believe, of a 3-10-0 fertilizer. The corn was backward early in the season, and on two adjacent fields as well as part of this field cottonseed meal was applied during the summer. Wherever the cottonseed meal was used the corn seemed to recover and made very satisfactory growth. This particular field, however, never made very much growth and was about the size of pop corn although it should have been good-sized yellow flint. Mr. Cannon says that when cultivating the corn it was easy to pull the whole plant out, as the roots seemed to be decayed, particularly in the center.

"I noticed in pulling up this stubble that some of the first roots had apparently disappeared and that secondary roots, although small in size, had developed. The application of cottonseed meal could be determined right up to the last row of corn, because in this field it was impossible to pull out the stubble where cottonseed meal was used, but the next row to it was like the specimens I send. I thought at first perhaps the fertilizer might have contained some borax, but nothing on the enclosed tag seems to warrant such an idea. Whatever the trouble was the cottonseed meal seemed to give the corn a new start so that a reasonable crop was secured."

It was of course too late for us to tell from the specimens sent the actual cause of the trouble, but we ran across a fungus that possibly may have had some bearing on it, and as we had never seen it before on corn, we have thought it worth while mentioning even if it should finally prove to be merely a saprophyte. In the pith of the stubble when cut across we found in the vicinity of the nodes the oospores of a fungus, see Plate LVI, 1, more or less abundant. As there were no other stages with these oospores, and as no cultures were obtained, we were not sure at first whether they belonged to a species of *Pythium* or *Phytophthora. Pythium deBaryanum* has been reported as dampening-off corn seedlings (Fischer, Die Pilze 1^4: 405.) but the oospores we found are too large for that species, and are enveloped too closely by the oogonium; besides there was a good stand of corn in the field. The oogonia varied from 21-33μ but

chiefly from 24-30μ and the oospores from 18-29μ but chiefly from 22-27μ. The walls of the oogonia and oospores were hyaline, and those of the latter were quite thick (2.5-4.5μ.) As a rule the oogonia enveloped the oospores rather closely and likewise the spores agree fairly well with those of *Phytophthora cactorum* in other respects, though the cell wall appears to be thicker than usual on spores in artificial cultures.

Infection experiments with the culture of *Phytophthora cactorum,* obtained from Pear, were not very successful on corn seedlings either in Petrie dishes or in soil in crocks. We did, however, in the latter get one or two seeds that showed oospores developed in them and a slight invasion of the main stem of the seedling. We have observed a number of root rots of different plants, especially in 1919, that were caused by *Phytophthora* or *Pythium,* and these we have discussed further under Pea, *q. v.*

Albinism, or *Striped Chlorosis.* Cases are not rare in both field and sweet corn where the young plants instead of being normally green have a whitish or yellowish-white color, or have similar elongated bands running lengthwise of the leaves separated by the normal green tissues. The more complete albinos never grow to large plants, and even the others are often somewhat stunted and may not mature seed. In 1919 several cases of the striped chlorosis were observed in Golden Bantam Sweet corn in the writer's garden and on a similar specimen of field corn sent to the station by G. D. Stone from Windham County.

Dr. Jones of this Station has grown experimentally several types of such corn and finds that when seed is matured the trouble is perpetuated more or less definitely as is the case with a number of our variegated plants cultivated for ornamental purposes. Just what prevents the development of chlorophyll in certain portions of the leaf and not elsewhere, thereby giving rise to this peculiar striping, is not known. Davis (Ia. Acad. Sci. 24: 459-60.) in 1917 conducted some experiments with chlorotic corn in Iowa that seem to show that this trouble is not communicated by handling or inoculation as is the mosaic of tobacco.

Pellucid Spots. Plate XXXVIII, a. The trouble shown in the photograph reproduced here was called to our attention during the summer of 1919. In June at Milford, Dr. Britton's men collected the first specimens from which the photograph was

made; and in July even more striking specimens were received from A. B. Case of West Granby. Dr. Britton was not able to identify the trouble as one caused by sucking insects, though it has somewhat that appearance. Neither did the writer in the fresh specimens find any fungus or bacterial agent as a probable cause. We place it here for the present as an indefinite physiological trouble. Later, in the dried herbarium material, sections showed some mycelium in the tissues but whether of a saprophytic or parasitic character could not be determined.

The pellucid, semi-watery, more or less zoned spots have somewhat the appearance of a bacterial trouble. In some specimens these spots are half an inch long and very numerous so that the intervening tissue is killed or the spots run together indefinitely. When first formed in the otherwise healthy leaf, they are quite striking in appearance. Usually there is a minute spot at the center which is apparently the point of entrance or starting point of the trouble. Mr. Case wrote: "The dead stalks like sample are scattered over the field, occasionally a whole hill infected, with good corn all around it, but usually only one stalk affected in the hill. There is one spot in the piece, however, covering two square rods, where nearly all the corn is affected. The corn was all fertilized alike."

Poor Seed. In 1917 corn, field and sweet, over much of the United States was of such poor quality that it was difficult to obtain seed of sufficiently high germination for the 1918 crop. While this was partly true of the Connecticut seed corn, apparently the corn here was not so severely hurt as in most other states. So that there was an unusual demand, from this state, for good field corn for seed purposes. Germination tests showed great variations in the corn, due in part to injury from the early frosts in the fall before the corn was thoroughly ripened, and in part to the poor care given in drying and storing afterwards. The severe winter of 1919-20 also produced somewhat similar injury but to a less degree. There is no question that, where corn is grown for seed purposes, as is considerable of the sweet corn in this state, more attention should be given to having it properly matured, dried and stored to avoid the injury that comes with cold weather. Much corn is stored in open corn cribs and great variation in germination of this

corn, after severe winters, is sometimes shown. Thoroughly dried corn or corn stored in warmer buildings does not seem to suffer so much.

Frost-injured corn usually develops wrinkles in the skin, that are quite visible to the naked eye. On germinating in the seed testers, this poor corn is also apt to become more or less moldy with a variety of saprophytic molds, much as does the *Fusarium* infested seed as shown by Hoffer. There is no doubt that such seed even if it does germinate will not give as complete or vigorous a final stand in the field as perfect seed. On the other hand it does not appear that the *Fusarium* is primarily responsible for the poor seed of 1919 so that we are not dealing with a serious field parasite that might be harder to control than poor seed due to improper conditions of harvesting and storing.

Cotoneaster, *Cotoneaster horizontalis.*

Red Canker, *Tubercularia vulgaris* Tode. This fungus was abundant on some dead stems sent us in Sept., 1916, by the Elm City Nursery Co., from Westville. Presumably the fungus followed winter injury, as it seems to be more of a saprophyte than a parasite. We have seen it a number of times on trees winter-injured, especially on nursery trees not strictly hardy in this climate.

Cucumber, *Cucumis sativus.*

Angular Leaf Spot, *Bacterium lachrymans* Sm. & Bryan. This disease shows as evident angular spots on the leaves as if water soaked. These at first are semi-transparent, but later are more opaque, reddish-brown, dead areas from which the tissues easily drop out. The bacteria also are said to cause a soft rot of the leaf petioles and young vines, and from small watery spots on the surface of the fruit Burger believes there develops a soft rot in the interior. This disease was sent us once or twice from Indiana some years ago, but we have only one collection on cucumber from Connecticut in the herbarium. This was found on the leaves at Milford in June, 1918. Our impression is that we have seen it at other times, but did not definitely identify it or collect specimens. However, we did collect specimens on musk-melons many years before this.

There is some question as to who first mentioned this trouble. So far as we have determined, it seems to have been first described in a popular way in 1894 by Halsted (N. J. Agr. Exp. Sta. Rep. 1893: 354-5.). He found it on musk-melons and reproduced a photograph of an infected leaf, but gave no scientific name to the bacterium producing the trouble. The writer found the disease first in Connecticut on the same host in 1902, and briefly mentioned it in his Reports (1903: 331. 1904: 346.) under the Bacterial Wilt disease with which we thought it might possibly be connected. It was collected at Southington, New Haven, Montowese, and seemed to be not uncommon in 1902 and 1903, but we have not collected it since. Burger (Phytopath. 3: 169-70.) in 1913 was apparently the first to make cultures and give a scientific description of the organism, which he placed under the genus *Pseudomonas,* but he gave no specific name. More recently, Dec., 1915, Smith and Bryan (Journ. Agr. Res. 5: 465-76.) gave a comprehensive account of the organism, which they call *Bacterium lachrymans.* These authors believe they studied the same leaf disease but concluded that Burger had a different organism in the soft rot of the fruit. It is quite possible that this organism opens the way for decay of the fruit by the ordinary soft rot bacteria. Some authorities would consider *Bacterium lachrymans* as a *Pseudomonas,* as it has polar flagella.

Currant, Black, *Ribes nigrum.*

Leaf Spot, *Septoria Ribis* Desm. This shows on the leaves as small, angular, brownish spots with a purplish border. The very minute, fruiting conceptacles are embedded as black dots in these. The linear spores are curved, hyaline, and chiefly 45μ by 1μ in size. The same fungus has been previously reported by us on red currants and gooseberries. The specimens on the black currant reported here were collected by the writer at the Nathan Hale homestead at Coventry, in June, 1917.

Rust, *Aecidium Grossulariae* (P.) Schum. This was collected on escaped black currants in North Stonington, June 20, 1919, by Mr. Stoddard of this department. It occurred on both the fruit and leaves. This was not the first collection in the state, however, as we have specimens in the herbarium on the same host

made by Thaxter at Green's Farms in 1889, and by Filley, near Bridgeport, in 1917. It has been reported before on cultivated gooseberries, but not on cultivated red currants, though it is quite common on various wild species of *Ribes* in the state.

Currant, Flowering, *Ribes odoratum.*

ANTHRACNOSE, *Glomerella cingulata* (Ston.) Sp. & v. Schr. The *Gloeosporium* stage of this fungus was found on the fruit of the flowering currant in a farm yard between Meriden and Middlefield, June 21, 1917, by the writer. The fruiting stage showed as numerous pinkish pustules on the half ripened berries. The spores were chiefly 12-15μ by 4-5μ. Apparently this fungus has not been reported, at least frequently, on this host. Saccardo described a species, *Gloeosporium tubercularioides,* as occurring on the leaves, but this, because of its wider spores, seems to be different from our species which we have also previously reported on the fruit of the red currant.

BLISTER RUST, *Cronartium ribicola* Fisch. Both the lemon-yellow dusty pustules of the II or summer stage and the hair-like spore columns of the III or mature stage of this fungus have been found on the cultivated yellow-flowering or Missouri currant in this state. This host is especially subject to the disease, being almost as much so as the black currant. The collections were made in each of the years 1916 to 1919. They were chiefly from the northern and eastern part of the state, in quite a number of different localities, at least twelve being recorded in 1916.

Currant, Red, *Ribes vulgare.*

BLISTER RUST, *Cronartium ribicola* Fisch. We have not reported the white pine blister rust on this host except incidentally in our 1915 Report, p. 423, where we noted that Spaulding found specimens near Meriden. There were only a few sori on abandoned bushes in the Middletown Water Company's Plantation at the Digby reservoir. Since then many other collections have been made in the state, the rust being common on abandoned or escaped currants in the woods in the vicinity of Norfolk and especially near the woodlands where the *Peridermium* stage on white pines is found. In 1916 thirty-eight collections were reported in twenty-six different towns or localities, and in 1917 an

even larger number of collections were made but mostly in the same localities. Since then the collections have been made each year but not to such an extent as the search has not been so thorough. While these localities reported are fairly well scattered over the state they represent chiefly the northern and eastern sections.

Mottled Chlorosis. We have occasionally seen isolated branches on currants where the leaves showed a conspicuous yellow mottling over the whole or part of the leaves. This may show as numerous small bands following the veins and enclosing equal angular areas of normal green tissue. The cause of this chlorosis we do not now know. Similar leaves have been seen on isolated branches of apple trees. Injury to the leaves in their very young state by sucking insects or by frost has been suggested as a possible cause.

Dewberry, *Rubus* sps.

Orange Rust, *Caeoma nitens* Schw. Germination tests seem to indicate that all specimens of this rust on wild species of *Rubus canadensis* in Connecticut belong to the short cycled form. We have not yet found this rust on cultivated dewberries. See Raspberry, in this Report, for further details.

Fir, Douglas, *Pseudotsuga mucronata.*

Grey Mold, *Botrytis cinerea* Pers. We are indebted to Mr. F. A. Bartlett for calling to our attention in August, 1919, this disease on Douglas Fir at the Rockefeller Estate, Greenwich. The fungus kills the young shoots of the season's growth, and develops a more or less conspicuous growth of the characteristic conidial stage on the dead tissues. The fungus occurs on a variety of herbaceous plants as a parasite under moist conditions.

This fungus has been also reported as causing injury to Douglas Fir in Germany by Tubeuf (Diseases of Plants: 269. Eng. ed.) who named it *Botrytis Douglasii* but Smith (Bot. Gaz. 29: 403. 1900.) considered it the species mentioned here, of which *B. vulgaris* is also given by him as a synonym. Some authors (See Duggar's Fungous Dis. Plants: 196.) consider *B. cinerea* as merely the conidial stage of *Sclerotinia Fuckeliana* DeBy.

Gooseberry, *Ribes* sps.

Blister Rust, *Cronartium ribicola* Fisch. The blister rust, both in its II and III stages, has been collected several times on cultivated gooseberries in the state during the last few years. However it does not occur so commonly or abundantly on this host as on the red currant, and much less so than on the yellow or black currants. Even when these other plants alongside of it are abundantly infected, it may escape infection entirely. This is probably only a specific characteristic of the gooseberries cultivated here, as certain species of native gooseberries, and others used in our infection experiments indoors, are easily and abundantly infected. Of the five collections made on cultivated gooseberries in 1916 and 1917, all were on plants in the northern or eastern part of the state.

Grape, *Vitis* sps.

Rot, *Pythium hydnosporum* (Mont.) Schroet. In August, 1919, E. V. Parr of Clinton sent us grapes that were badly diseased. This was chiefly due to the black rot fungus which was very prominent that year, though some injury was also caused by the grape berry moth. Other fungi present apparently followed as saprophytes, of which the *Pythium* named above was the most conspicuous. It is a fungus that is not reported, at least prominently, in American literature. We have seen it occasionally developed in rotten potato tubers, the original host, following injury by *Phytophthora infestans,* and have also found it on pea roots (kept in water) injured by the *Phytophthora cactorum* mentioned in this Report. On these rotting grapes, however, we found it developed more prominently than ever before.

The oospores in certain grapes were very abundant, in some being produced within the pycnia of the black rot as if belonging there naturally. They were also found in the grape tissues and even in the bodies of the larvae infesting them! The oogonia (see Plate LVI, 9) are very striking because of their fairly numerous conspicuous spines. These reach out to 2-5μ beyond the oogonial wall and are often quite sharply pointed but with age they may become blunter and less conspicuous. The smooth spherical oospore is often so closely enveloped by the oogonium

that this resembles one of its coats. With age the oogonia are tinted and, including the spines, measure from 20-27μ in diameter, while the oospores vary from 15-20μ with their thick wall from 2.5-3.5μ. No other stages were seen by us and according to Winter, who calls it *Pythium artotrogus,* none have been found. It is now placed under the sub-genus *Artotrogus* (under which it was originally described by Montaigne) because of the spiny oogonia.

Lightning Injury. In July, 1918, we had called to our attention at Marlborough, lightning injury of grapes. According to the owner, Mr. d'Esopo of Hartford, a year or two previous lightning had struck the two wire trellis along which the Clinton variety of grapes was trained. Within a day or two all the branches that were attached to the wires were dead. However, the main stem was not killed and new runners were quickly developed from this, so that at the time we saw them they were as vigorous as ever. Prof. Hollister, who was with us at the time, stated that he had seen similar injury to grapes at Bolton Notch.

Smoke Injury. We were called in September 1919 to examine serious smoke injury to a variety of plants in the suburbs of New Haven. There was a difference of opinion as to the cause of the injury, some claiming that it came from an aluminium factory and others from a brick kiln. After our examination of the vegetation in the vicinity of each, we had no hesitancy in deciding that the brick kiln was the responsible agent. The kiln was situated along the railroad, and the smoke had been carried in a west southwestern direction until it struck against the hillside of East Rock Park. From the slopes of this going toward the kiln, one could trace all the way in a direct line, damage to a variety of trees, vines and herbs.

In the park gray birch, beech and hornbeam were the trees most injured. Hemlock, hickory and maples here showed the least injury. However, in 1910 (Rep. 1909-10:722.) we saw serious injury to conifers, especially young spruce, in this same park from another brick kiln. Maple and elm trees, midway of the park and the kiln, showed the trouble more or less prominently according to their situation. Part of the injury to the maples, however, may have been due to sun scorch as we are

unable to tell these troubles apart from the appearance of the leaves. Corn, tomatoes and some trees and weeds near the kiln were also injured. Grapes in a number of the yards midway showed the trouble as conspicuously as any of the plants. Their leaves were badly scorched and some of the young twigs suffered injury at their base. The ripening fruit was insipid and was dropping considerably. The few peach trees seen did not seem to be injured, which agrees with Stone's statement, *loc. cit.*, that this tree, with black locust and *Ailanthus*, is more immune than most trees.

As we have heard of injury to vegetation from at least three brick kilns in this state, it might be well to give here the conditions under which, as we understand them, this damage occurs.

In the first place the injury is chiefly due to the sulphur dioxide in the smoke that comes from coal in the fires and particularly from the coal dust mixed with the bricks to help burn them. As these become red hot it is necessary at a certain time in the firing to lift the board covers of the sheds to avoid fire and let out the heat and smoke. If this takes place on a wet or muggy day and the smoke is driven toward the ground and comes in contact with the damp foliage, a burn results, probably due to the formation of sulphurous or sulphuric acid. If the day is fair and the smoke ascends no damage results. So only occasionally, when all conditions are right, does injury to vegetation follow. Smoke injury is not always due to sulphur dioxide, but other gases and sedimentary deposits sometimes cause injury in specific cases.

In our Report for 1908 we mention briefly smoke injury to asparagus from a brick kiln and in the present one describe injury to apple (*q. v.*) by smoke from a bronze factory. Smelters, particularly in the western United States, cause such great injury that much special investigation has been made in recent years by botanists and others. Hedgecock (Torr. 12: 25-30. 1912. Journ. Wash. Acad. Sci. 4: 70-1. 1914.) has briefly described such injury in Montana and Tennessee. Bakke (Ia. Agr. Exp. Sta. Bull. 145: 383-409. 1913.) gives a more detailed account, with references to literature, upon "The Effect of City Smoke on Vegetation," while Stone (Mass. Agr. Exp. Sta. Bull. 170: 228-32. 1916.) treats of the effect of atmospheric gases on shade trees, in a popular manner.

Winter Injury. The d'Esopo vineyard, previously mentioned under Lightning Injury, is situated on a high ridge in Marlborough and is the largest vineyard in the state, consisting of about one hundred acres. For some years the Italians have been gradually going into growing grapes and this fruit is therefore becoming more prominent while the peach is becoming less so. As comparatively few grapes have been grown here commercially, except in a small way, the troubles of the vine require more notice than has been given them in the past.

We wish to call attention here to a very serious trouble that developed in this vineyard, chiefly on Concords, which with Professor Hollister of Storrs, we were asked to investigate. It was first noticed in the early summer of 1917 when the vines in some cases produced a scanty or sickly foliage and in a few cases died outright. Mr. d'Esopo thought some unknown disease was at work, especially as in 1918 the trouble became more conspicuous. Our examination, made July 18, soon convinced us that the trouble was entirely winter injury, due in part to a lack of snow mulch in 1916-17, but more particularly to the very severe winter of 1917-18. The vines most injured were on a ridge. Some of these were dead, others dying, or with more or less scanty foliage, and some apparently in fair shape. We found the wood of the sickly vines to be sound, but an examination of the roots showed these were injured and in some cases, especially those nearest the surface of the ground, partly or entirely dead. The condition of the foliage above ground corresponded so closely to the condition of the roots beneath that one could not doubt that it resulted from this diseased condition of the roots. There was nothing on the roots to indicate a parasite as the cause of their death, one peculiar saprophytic hyphomycete on certain dead roots being the only fungus seen.

There was no question that winter injury was the cause since complaints of winter injury to fruit trees from these two winters, especially the last, had been greater than for many years. Many peach trees on this farm had been killed. Then, too, the exposed high elevation of the grapes had been favorable for such injury and we had another complaint from the neighborhood of Colchester of similar injury under such conditions although the grapes in both localities had received good attention.

Most persons are likely to overlook winter as the cause of much injury to grapes since it often does not become manifest until early summer, after the foliage has been put forth, when the leaves die quickly under the hot sun or dry weather conditions. The winter is much harder on the roots than on the vines above ground. Often the roots are dead or badly injured when the vines and buds are uninjured, but while the buds may develop they cannot live, or only a portion can live if the roots are not too severely injured. In the latter case good cultivation and fertilization early in the season to stimulate new root growth is desirable. Snow or other mulch of course is helpful in preventing the trouble. Wet spots and shallow soil are to be avoided as being more likely to favor winter injury. Selection of hardy varieties, where possible, is also to be taken into consideration although the Concord, more or less subject to injury, is the most common variety grown.

Hickory, *Carya* sps.

Connate Fomes, *Fomes connatus* (Weinm.) Gillet. Plate XXXVIII, b. This fungus is called *Fomes populinus* by Murrill. The specimen shown here was collected Nov. 25, 1918, on a living hickory tree in the woods between New Haven and Milford. The bracketed pilei in this cluster were much larger than we have seen them on the maple, the ordinary host in this state, being 4 by 4 by 8 inches. The upper surface of the pileus is whitish, with age becoming blackish or greenish with algal growth behind. The under or fruiting surface has more of a flesh color, the rather small and thin pores often having a satiny lustre. The pilei are irregular, with small shelves often growing into the larger. The stratified pores, characteristic of the genus, are evident but often irregularly placed.

This species differs from most of the *Fomes* found in this state by the less woody and more corky pileus especially its context. Murrill (Northern Polypores: 47.) says: "Rather common throughout on living trunks of maple and certain other deciduous trees, causing decay."

Witches' Broom. Plate XXXVIII, c. This trouble of *Carya ovata* was first called to our attention in 1917 by Mr. E. B. Harger of Oxford, Conn., and we have seen specimens from his trees each

year since. Swollen places show on the branches and from these several secondary branches are formed giving the witches' broom effect. The leaves drop off prematurely, often leaving the petioles still attached to the limbs. The morbid growth eventually dies, killing the parts beyond. Mr. Harger has observed about a dozen hickory trees so affected on his place and thinks the trouble is spreading slowly although not many of the branches on a tree are yet involved.

We were unable to find any indications that this was an insect injury and very little evidence that it was caused by a fungus. No fruiting stages have yet been seen on any of the branches. Mr. Stoddard, in examining the wood microscopically, found a little evidence of mycelium in one specimen but was unable to obtain cultures of a fungus from the tissues of the morbid growths. Of course it is possible this trouble is merely a stag-head growth developed through winter injury of the terminal bud or tip of the twigs.

Honeysuckle, Hall's, *Lonicera japonica* var. *Halliana.*

Crown Gall, *Pseudomonas tumefaciens* (Sm. & Towns.) Stev. This bacterial disease was sent us on the above host, new to the state, from the Elm City Nursery in June, 1918. It was not causing any great damage, showing as small galls on plants in storage.

Horsechestnut, *Aesculus Hippocastanum.*

Anthracnose, *Glomerella cingulata* (Ston.) Sp. & v.S. Plate XXXIX, a. Specimens of this disease of horsechestnut were sent us about the middle of August, 1917, by Mr. C. F. Crosson and a short time later we examined the tree from which they came. The tree was in the yard of Mr. George Wilcox at Meriden. Many of the leaves showed a bad scorch-like injury and were dropping prematurely. Often only part of the leaflets or a portion of the blade of a single one showed the reddish-brown injury, the rest remaining the usual green color, as shown in the photograph reproduced here. An examination of the tissues of the blades, the midribs and the petioles revealed the presence of both the *Gloeosporium* and asco stage of the above fungus.

So far as we know this is a new, or at least an unusual, host

for this fungus as it is not reported in Saccardo's or Farlow & Seymour's Host Index or by Shear and Wood in their bulletin on Glomerella. The tree was in a sickly condition, other than from the action of this fungus on the leaves, apparently due to winter injury. Whether or not this weakened condition of the tree influenced the appearance of the anthracnose on the leaves we do not know, but there was no doubt that it was occurring there as an active parasite.

Red Canker, *Tubercularia vulgaris* Tode. Plate XXXIX, b. This was collected on the branches of the winter injured tree mentioned above. The fruiting stage breaks through the bark as numerous, small, firm, pinkish pustules. It seems to be at most a weak parasite and is the conidial stage of *Nectria cinnabarina* (Tode) Fr., with which it is often associated but was not in these specimens.

Winter Injury. Besides the above horsechestnut tree, which showed dead branches and some winter cankers due to the unusual exposure on a terrace to the western sun, we had specimens sent us from Wallingford, by Mr. C. H. Brown, of a rather unusual winter injury. The leaves on certain branches from this tree developed later and were much smaller than those of the rest of the tree. On cutting those twigs lengthwise, the pith in the previous year's growth was found to be, especially at the nodes, turning a reddish-brown color. This winter injury no doubt had been sufficient to interfere somewhat with the transference of the starch, as it was present here but not in the normally white pith, with the result that while the leaves were put forth they did not reach their full size through lack of sufficient food for normal growth.

Hydrangea, *Hydrangea paniculata* var. *grandiflora.*

Chlorosis. We know of no variety of this cultivated plant that is variegated. In a yard near the Station is a plant certain of the leaves of which showed a whitish mottling, in the fall of 1916. Usually these small spots ran more or less together and were situated in the vicinity of the larger ribs or at the margin of the leaves. The mottling was quite varied in pattern, in one case forming a nearly complete, narrow, banded circle at the apex of a leaf. In some respects the trouble appeared like

insect injury to the leaves when very young which prevented chlorophyll formation at these spots.

Kohlrabi, *Brassica oleracea* var. *caulo-rapa.*

Club Root, *Plasmodiophora Brassicae* Wor. Plate XXXIX, c. This slime mold disease of cruciferous plants, showing on the roots as irregular knobs or gall-like growths that eventually rot off, has previously been reported by us on Brussels sprouts, cabbage and turnips (both yellow and white) and is recorded here on radish, *q. v.* It was found on the roots of kohlrabi sent the Station in June, 1918. Club root was unusually common that year being most frequently found on cabbage, the only host on which we have found it causing very much damage in the state so far. Badly infected cabbage plants fail to grow, in many cases turning yellow and dying prematurely, or at best making small heads. While the germs become established in the soil and infect plants each year, certain seasons seem to favor their development more than others. The season of 1918 was much more favorable than that of 1920.

Larkspur, *Delphinium* sp.

Fasciation. A specimen showing fasciation of a single fruiting stem of a cultivated larkspur from the garden of Mrs. E. D. Driesbach, Whitneyville, was collected by Mr. Stoddard in July, 1919. The flattened two-foot stem in this case was about half an inch wide, or twice its normal diameter for the entire length. The upper half of the stem was occupied by the seed pods and had a half curl part way up. The top was forked for a short distance but the tips were not coiled. See Asparagus.

Lettuce, *Lactuca sativa.*

Bladdery Peziza, *Peziza vesiculosa* Bull. Specimens of this fungus were sent us in May, 1918, by Mr. Gordon J. Gale, Garden Supervisor of Bridgeport, who found them in a cold frame of lettuce. They did no harm, except from crowding the plants, as the fungus is a saprophyte developing only on the humus in the soil. This is one of the cup fungi, occurring in thick clusters of semi-globose cups (often flattened by pressure) which are closed at first but later open by an incurved broad mouth. The sessile cups are an inch or two in diameter.

Concerning the fruiting receptacles Hard (Mushrooms, Edible and Otherwise: 508. 1908.) says: "They are found on dung hills, hot-beds or wherever the ground has been strongly fertilized and contains the necessary moisture. This is an interesting plant and often found in large numbers."

Maple, *Acer* sps.

CONNATE FOMES, *Fomes connatus* (Weinm.) Gillet. We have seen this species several times on maples, especially on living red maples at both Woodbridge and Union. It is more or less of a parasite, chiefly causing decay of the heart wood. Under Hickory it is described more in detail.

Mountain Ash, *Pyrus americana.*

RUST, *Roestelia cornuta* (Pers.) Fr. So far we have found this rust only at Norfolk, Conn. We remember seeing specimens several years ago on American mountain ash trees in the golf grounds there and in June, 1919, collected specimens of the spermagonial stage on the same host at the edge of woods in the same general vicinity. Very near these small trees, whose leaves were rather abundantly infected, we found the III or mature stage on *Juniperus communis.* On the mountain ash the fungus makes conspicuous yellow spots, showing on both sides of the leaves, with the spermagonia quite evident on the upper and the aecia in time appearing on the lower. This fungus is a northern species, apparently, specimens having been sent us from both Massachusetts and Maine where it seems to be more common than in Connecticut.

Farlow (Host Index: 199.) also gives *Aecidium globosum* on this species of mountain ash and Kern (Bull. N. Y. Bot. Gard. 7: 434. 1911.), while he lists six species on Sorbus, gives only these two on *Pyrus* (*Sorbus*) *americana.* Concerning the III stage, *Gymnosporangium cornutum* (Pers.) Arth., Arthur (Myc. 1: 240. 1909.) says: "Telia on branches of *Juniperus Sibirica* Burgsd. were collected May 19, 1908, by Mr. F. D. Kern and Mr. E. Bethel, at Palmer Lake, Colo., and sown May 23, on *Sorbus americana,* giving an abundance of pycnia June 1, followed by numerous aecia. * * * Although the horn-like aecia of this species are common and often collected, this is the first time that the telia have been found in America." Thaxter

(Farlow Bibl. Index: 36. 1905.) however, seems to think the proper name of the mature stage is *Gymnosporangium conicum,* as he says: "Since what is believed to be the true *Gymnosporangium conicum* D. C. occurs in New England and northward on *Juniperus communis,* the citations of *Aecidium cornutum* on *Pirus americana* in those regions probably refer to the true *Aecidium cornutum* of Europe."

Musk Melon, *Cucumis Melo.*

Angular Leaf Spot, *Bacterium lachrymans* Sm. & Bryan. Although this bacterium was described originally on cucumbers (*q. v.*) there seems to be no reason for doubting that it causes the similar disease on musk melons mentioned by us in our 1903 and 1904 Reports.

Oak, *Quercus* sps.

Pink Rot, *Cephalothecium roseum* Cda. This fungus was brought us in July, 1916, by the entomological inspectors, on specimens of *Quercus rubra* recently imported by a nursery from Holland. They had just been transplanted and the stems were dying, a growth of the above fungus developing on them. We have little doubt that the trees were injured by long continued or poor storage on ship-board, perhaps developing scald from improper watering and heating, and that this fungus came as a result and not as the cause of injury. During the war, shipping conditions were very bad and many shiploads of plants were lost or greatly injured because of slow delivery.

Sulphury Polypore, *Polyporus sulphureus* (Bull.) Fr. Plate XXXIX, d. Large fruiting clusters of this fungus were found on a living oak shade tree at the Barnes Nursery, Yalesville, in September, 1917. The fungus was doing considerable injury to the tree, possibly having got a start through winter injury of the bark. It is one of the larger and more attractive polypores. When young the fruiting brackets are quite compact, as shown in the illustration, and are fleshy and moist, but with age they develop into more flattened, shelf-like, overlapping pilei that in drying become corky and brittle but are not so durable as the real woody kinds. The upper surface has a reddish or orange color, and the lower, poroid, fruiting surface a decided sulphur yellow. The flesh is white. It is not uncommon as a saprophyte.

Cooke (Fungoid Pests Cult. Plants: 208: 1906.) says of it: "This large and attractive looking polypore is a wound parasite on several trees such as oak, alder, willow, poplar, and even pear and apple, as well as larch." Von Schrenk and Spaulding (Bur. Pl. Ind. Bull. 149: 37. 1909.) write, "It is widely distributed throughout the United States and Canada and in most of the forest regions of Europe, where it is regarded as a destructive parasite, both on deciduous trees and conifers."

White Heart Rots, *Fomes igniarius* (L.) Gill. and *F. Everhartii* (E. & G.) v. Schr. & Spauld. By European authors the first of these large, perennial, woody fungi has been given the common names of False-tinder fungus or Rusty-hoof Polyporus. It is not uncommon in this section of the country on various hard woods, but so far in this state we have seen it only upon oak and apple, *q. v.* As we have observed this fungus, it first develops as rounded, smooth, ferruginous knobs on the trunks. In time these growths show a differentiation into upper and lower surfaces, the upper becoming greyish in color and the lower ferruginous surface developing the small fruiting pores; the shape now has become somewhat ungulate or even more flattened. With age the upper surface turns black and is somewhat zonate and cracked but still with a ferruginous, smooth, obtuse margin separating it from the poroid surface. The spores are said to be hyaline but we have failed to find them on the specimens we have examined. The stuffed whitish tubes also are somewhat characteristic.

Von Schrenk and Spaulding (U. S. Bur. Pl. Ind. Bull. 149: 25-37. 1909.) give a comprehensive description of the fungus and its injuries in their bulletin on "Diseases of Deciduous Forest Trees." It is considered quite a serious wood rotting fungus, causing the heart wood especially to become broken up into a whitish punk, hence the common name of the disease. It also injures the living wood and bark slowly. The fungus not only renders the wood unfit for timber but weakens the trees so that they are more easily blown over. It is said to gain entrance through wounds and often fruits near its point of entrance. We noticed it for several years on a street tree of *Quercus velutina* in New Haven. Each year the fruiting bodies were cut off but reappeared, in time, with the disease slowly ex-

tending in the bark until finally the tree was cut down because of the injury.

The second species was originally described by Ellis and Galloway (Journ. Mys. 5:141. 1889.) as *Mucronoporus Everhartii* and has since been placed by Murrill under both *Pyropolyporus* and *Fulvifomes,* but in the opinion of the writer belongs better under the more comprehensive genus *Fomes,* characterized by layers of fruiting tubes formed in superimposed strata each year. This species is much like the former in appearance and is sometimes mistaken for it but the upper surface becomes more cracked and rougher with age and the strata of tubes are more reddish without much evidence of the white stuffed appearance and easily yield an abundance of ferruginous spores. Von Schrenk and Spaulding, *loc. cit.* p. 48, state that the action on its host is much the same as that of the other species. We have found it only once in this state, on a living oak near Lake Congamond in June, 1916.

Onion, *Allium Cepa.*

During the last five or six years some attention has been given by us to the onions which are grown for seed in this state. This seed-growing has been quite an industry in the past but the great uncertainty of a crop, due largely to the so-called "blast," has discouraged most farmers from growing onions in recent years. In our study of the blast we have noted various troubles and abnormalities, mostly of a non-parasitic nature, which we briefly describe here. For Blast see Plate XLII, a.

Rust, *Puccinia Porri* (Sow.) Wint. We reported (Conn. Agr. Exp. Sta. Rep. 1915:438. 1916.) the II stage of this fungus, found on Ægyptian perennial onions at Storrs, in 1914. We have since collected it on the same plants several times but the collection on Nov. 17, 1917, was the only one where we found the III stage, thus completely establishing the identity of the rust. Apparently this mature stage develops rather late.

Yellow Leg, *Fusarium* and *bacterial* rots of bulbs, etc. This trouble usually shows when the onions are fully grown, but not matured, by occasional stalks turning yellow below and finally dying before fully maturing their seed. Such stalks are easily pulled from the ground, as the roots have been largely rotted off.

Generally *Fusarium* or bacteria are the cause of this rot and these may come from the old bulbs, possibly developing there largely as saprophytes. Damp weather and poor bulbs favor the trouble.

Bastard Blossom. Plate XL, a. This is a common name applied by growers to occasional abnormal heads that appear in the field, the appearance of which is well shown in the illustration where two such heads are contrasted with the central normal one. These heads have the individual pedicels more elongated, so the flowers spread out in a larger laxer bunch. Growers complain that little or no seed is developed, so they pull them up when seen, but whether the seed that is produced tends to form similar plants we do not know. The reason little seed is produced is because the pistils are often changed into foliacious structures. Sometimes the heads fail to form blossoms at all, but in their place form numerous slender stem-like growths from little bulbils.

Bulblet Head. Plate XL, b. Occasionally the plants, instead of producing a blossom cluster at the end of the stalk, form a bunch of bulblets in the same place, as is often seen in wild species and some cultivated varieties. Rarely we have found specimens like that shown in the illustration, where after these bulblets were started the stem continued on above and also formed a smaller flower cluster. The specimen figured here also shows another trouble which we call "Goose Neck."

Double Flower Head. Plate XL, c. Occasionally instead of a single flower cluster on the end of the stem there may be two, a lateral one below the other. Usually these are about the same size and but a short distance apart, though we have also found specimens where the lower one was much farther down the stem and quite small.

Elongated Spathe. Plate XLI, b. Normally the flower head is enclosed when young by a small spathe that later becomes ruptured and withers up at the side as a sort of bract. Occasionally, however, it is more permanent and pretentious, continuing as a pointed extension of the stem, which the blossom finally forces to one side, as shown in the illustration.

Goose Neck. Plate XLI, a. This is a term we have coined for those not infrequent crooks in the stems that develop all

the way from a slight bend to a completely coiled turn or even a turn and a half, as shown in one specimen in the plate. We cannot be sure of the cause of these but suspect that during rapid growth the stem is sometime bent to one side, from one cause or another, and this produces turgor that results in more rapid growth on the opposite side and the resulting curvature. Possibly in pushing through the bulbs the stem is sometimes caught at the tip and before this is released the stalk has made a bending exit. The natural tendency, after the bending has become prominent, is for the tip to again grow upwards, hence many half turns, bends, etc.

Hail Injury. Plate XLI, c. We saw rather severe injury to a field of Southport White Globe seed onions in Milford, caused by a hail storm on July 27, 1917. As usual there soon showed on the side of the stalks from which the storm came the characteristic white spots or marks that we have found with hail injury to tobacco, *q. v.* Corn in an adjacent field also showed a little of a similar injury. Plate XLI, c, shows three hail-injured onion stalks, two showing the injured sides exposed to the hail and the other with the uninjured side protected from it.

White Ring. Plate XLII, b. This trouble shows as narrow white rings or cracks extending more or less completely around the stem. They apparently start as a small break in the epidermis which extends crosswise around the stem but whether gradually or suddenly we do not know. These rings may be single or several parallel to each other and are always found somewhat above the bulge on the lower part of the stem. If they extend deeply into the tissues the stem often breaks off at one of them.

At first we thought that they were the result of insect injury but finally decided that they are growth cracks. The epidermis of the stem is very thick and the stem makes a rapid growth of three or four feet in a few weeks at most. This stretches the epidermis greatly, especially longitudinally, with the result, in our opinion, that cracks develop at the place of greatest strain which appears to be above the bulge on the stems.

Under the designation of "Crack Neck" Chapman has recently described (Phytopath. 9: 532-4. 1919.) and illustrated a trouble of chrysanthemums very similar to this. The causes he states as follows: "(1) Very little transpiration takes place as a re-

sult of the low air temperature and the high humidity, and (2) the soil temperature remaining practically stationary, the soil having been previously well supplied with moisture; and the roots functioning normally in so far as the absorption of water and solutes was concerned. These and similar conditions always bring about abnormal cell relations and in consequence an excessive turgor is brought about in some of the cells with no normal means of regulation, such as occurs when the plants are transpiring freely, and as a result some of the tissues must give way to permit of a return to the normal condition."

Pea, *Pisum sativum.*

Root Rot, *Phytophthora cactorum* (Cohn & Leb.) Schroet. Early in July, 1919, Mr. A. N. Farnham, a large market gardener of Westville, sent to our office samples of pea vines that were being killed by some unknown agent. The vines at this time were in their prime, the first picking not yet having been made. The vines eventually turned yellow and wilted down, so that, except for the one or two small early pickings, there was practically no crop in a field of several acres. A visit to the field showed that the trouble started as a root rot, but in time the stem also rotted somewhat below and both became invaded by bacteria, nematodes, etc. Other fields in the vicinity showed the same trouble, which had little or nothing to do with the manner of fertilization or rotation. Afterward complaints came in from growers in Milford, Waterbury, Bloomfield and Winsted. The trouble was also seen in the writer's and in the Station's garden. Very similar troubles have been caused in previous years by both a *Fusarium* and a *Rhizoctonia* fungus. While these may have been the cause of the trouble on some vines this year, we could not find them generally present, and so were inclined to look elsewhere for the chief cause.

With many of the specimens it was difficult to find, on ordinary examination, any fungus apparently guilty of the trouble. Continued search, coupled with sections of the tissues, however, usually revealed the presence of oospores of a phycomycetous fungus more or less prominent in certain of the tissues. This was especially true of the Farnham field where we had the best opportunity for studying the trouble. We finally came to the conclusion that this fungus was at least the original agent in

starting the trouble and that its development might be rather local in the underground parts. It was too late to study the disease in its beginning, but it did not seem to act like the ordinary dampening off caused by *Pythium de Baryanum,* especially since no complaints of a poor stand were received. We found the oospores, occasionally with attached antheridia, chiefly in the outermost tissues which also contained the prominent intercellular mycelium that gave rise to them. No signs of any other stage was found, and apparently the mycelium in later stages of the rot did not develop so prominently, being crowded out by other rot agents.

The oogonia were chiefly hyaline but with age in the old specimens became somewhat tinted yellowish-red and the wall (1-2μ thick) wrinkled. They varied from 24-36μ but were chiefly 27-33μ in diameter. The thick walled (2-4μ) smooth oospores varied from 20-30μ but were chiefly 22-27μ in diameter, and from oval to chiefly subspherical in shape. The oval shape was apparently due to pressure when formed within the plant cells. When we first tried to identify this fungus from the oospores found in the tissues, we were uncertain whether it was a *Pythium* or a *Phytophthora.* Naturally *Pythium deBaryanum* suggested itself, but the fungus failed to form any external mycelium when specimens were placed in water. The oogonia and oospores of *P. deBaryanum* as seen by us on Spinach (*q. v.*), also in a culture received from Washington and as given by Fischer (Die Pilze 1^4: 404. oogonia, 21-24μ; oospores 15-18μ), were considerably smaller than those found in the pea roots. Furthermore Fischer states that Hesse failed to infect *Pisum* with *Pythium deBaryanum* in his infection experiments. Atkinson (Corn. Agr. Exp. Sta. Bull. 94: 245. 1895.) gives an extended description of *Pythium deBaryanum* that agrees with these others but not well with our pea fungus. On the other hand Jones (Phytoph. 10: 67. Ja. 1920.) has recently published a note on pea blight in Wisconsin, etc., occurring in 1919, that he attributes in part to "*Pythium* (probably *deBaryanum*)." Various references exist in literature (Tubeuf and Smith Dis. Plants, p. 117; Zeitschr. Pflanzenkr. 2: 253.) to a *Pythium Sadebeckianum,* described by Wittmack from Germany in 1892, as causing serious root rot of peas and lupins. We have not seen the original reference and have not been able to find any

description of the fungus giving measurements of the oogonia and oospores. It is possible that this is the fungus we have found and that it is quite distinct from *P. deBaryanum.*

On the other hand the fact that Hesse failed to infect peas with *P. de Baryanum,* and the absence of any definite sporangia, so far as we could determine, and the agreement in size of the oospores and oogonia with *Phytophthora cactorum,* has led us to conclude that this latter is the fungus that we have been dealing with. Our preliminary infection experiments of peas in Petrie dishes and crocks with *P. cactorum* from Pear also indicated that under certain conditions infection of the seeds and roots may take place, though apparently not so abundantly or seriously as similar infections with *Pythium deBaryanum.* Apparently moisture conditions and the stage of the cultures are important factors in the results.

Phytophthora cactorum seems to be a soil fungus and is accused of causing root and stem rots in a great variety of plants in Europe. It was present to an unusual degree in Connecticut in 1919, as shown by rotting pears and apples on the ground. The year was very moist and favored this unusual development. The injury to corn (*q. v.*) already mentioned, and the fact that in 1907 we found similar oospores in the roots of rotting sweet peas, also help us to the conclusion that in very wet situations or moist years this fungus may be responsible for more or less obscure root rots on a wider range of hosts in this country than have yet been reported. It is very desirable that cultures from various plants be obtained for definite comparisons and inoculation experiments. It is not easy, however, to obtain cultures under conditions of rot as produced on the pea vines.

In comparing the oogonia and oospores of these fungi in cultures with those found in the rotting tissues in nature, it is well to remember that under the latter conditions, especially in old dried specimens, one is liable to find the walls more deeply tinted and thicker, and the oogonial walls often wrinkled or folded. These variations might lead one to suppose they are specific differences, when they are merely due to the different conditions under which the spores are produced. In Plate LVI, Dr. McCormick has made drawings of different species of *Pythium* and *Phytophthora cactorum,* as produced in artificial cultures and as found on various hosts in nature, in which we

have tried to bring out specific differences and the environmental variations in the same species.

For further discussion of *Phytophthora* and *Pythium* rots in this Report, look under the following: Apple, Celery, Corn, Grape, Pear, Sweet Pea and Spinach.

Root Rot, *Fusarium* sp. Specimens of garden peas showing this root and stem rot were first received from C. A. Weatherby of East Hartford in July, 1917, and in June, 1918, others were sent by J. H. Taylor of Middletown. The general symptons are very similar to those mentioned in the preceding trouble. The plants usually attain fair size and may even start to blossom when they turn yellow and wither away. An investigation shows that the base of the stem and roots have been rotted away so that the vines are easily pulled from the ground. Microscopical examination of the tissues reveals the mycelium of a *Fusarium* rather abundant and extending up into the healthy tissues. Some microconidia may be found, but if the specimens are placed in a moist chamber usually an abundance of a white or pinkish mycelium appears over the tissues with both macro- and microconidia. Besides the *Phytophthora* and *Fusarium* mentioned here, *Rhizoctonia* also causes a similar trouble. Wet weather plays a very prominent part in the development of all these fungi. Care in the use of manure, rotation and frequent cultivation to keep the top soil dry, help to control these troubles.

Pea Shrub, *Lespedeza Sieboldi.*

Fasciation. This abnormality was called to our attention by Dr. Britton who, while inspecting the Steven Hoyt & Sons' Nursery at New Canaan, in the latter part of August, 1917, found a couple of stems of a plant of this Japanese shrub-like herb that were very abnormally flattened. These or similar stems were seen at the same place in May by Mr. Zappe. They were at least 18 inches in length and where broken off were still flattened so that they may have formed quite an extended flattened stem as the plant, which grows in bunches from the ground, sometimes reaches a length of six feet. Like other fasciation we have seen, the leaves were scattered apparently irregularly over the stem and the top was recurved or coiled for a couple of turns. One specimen had the usual bifurcated coiled tips of approximately the same size, while the other had a much smaller

side branch. In each case the two branches coiled to the same side. Under Asparagus in this Report, pp. 415-17, we call attention to the similar fasciation on that and other plants.

Peach, *Prunus Persica.*

Die Back, *Valsa leucostoma* (Pers.) Fr. Plate XLIII, a. This trouble was first called to our attention in 1917 by Mr. N. S. Platt who complained that it was causing serious injury to his orchard at West Haven. We have examined the orchard several times and have seen cankers of all sizes from small dead spots on the twigs to large cankers, on the main branches, several inches in diameter and the bark entirely gone. Often these develop at the base of a dead twig or branch and are much like winter injury cankers with which we believe the trouble to be closely connected. Mr. Platt, with more or less success, has tried to control the trouble by carefully cutting away these cankers each winter.

At first we thought the trouble might have some connection with the brown rot as the cankers much resemble those described by Jehle (Phytopath. 3: 105-10. 1913.). We failed, however, to isolate this fungus from the injured or dead tissue. After some failures we finally in 1918 succeeded rather uniformly in obtaining cultures of the *Cytospora* stage of the *Valsa* here named and later were able to find this conidial stage more or less abundantly on the infected branches. Rolfs (Mo. St. Fruit Exp. Sta. Bull 17: 1-101. 1910.) made an elaborate study of this trouble and its cause and came to the conclusion, partly through inoculation experiments, that this fungus was largely responsible for similar injury to peaches in Missouri.

Winter Injury. Plate XLIII, b, shows a neglected and winter injured peach orchard at East Wallingford. During the severe winter of 1917-18 many trees were killed or badly injured. Our experimental orchard at Yalesville, although most of the trees were severely hurt and some killed, was saved by vigorous pruning and liberal fertilization with sodium nitrate and has since made a splendid growth.

Pear, *Pyrus communis.*

Downy Mildew Rot, *Phytophthora cactorum* (Cohn & Leb.) Schroet. Plate XLIV, a. We first found this fungus on pears

sent us the last of September, 1919, by A. B. Beers of Bridgeport. These pears had been picked and stored but when ripening started rotting apparently from the inside. This was a soft rot, the slightly discolored and diseased tissues easily separating from the healthy and forming darker or reddish-brown areas on the skin, with no signs of any spore stage, as shown in the illustration. The microscope revealed a non-septate, prominent, laxly branched mycelium, rich in oil-like drops, running between the cells. Sometimes there was a sidewise branch and occasionally two or three with one taking the place of the main branch and these varied in width from 3-9μ. There was no indication whatever of any spore stage. The mycelium was evidently of the same type as that found in the peculiar rotting of stored apples that were sent in for examination in 1918, brief mention of which has already been made under Apple in this Report.

Petrie dish cultures were easily obtained on oat agar and these produced a great abundance of oospores imbedded in the medium, but no aerial growth bearing conidia of any kind. We were not sure from this whether the fungus was a *Phytophthora* or a *Pythium*. However when the fungus was transferred with a bit of the medium to water in van Tieghem cells the typical conidia of *Phytophthora* were produced. A study of the cultures in both stages led us to the conclusion that the fungus was *Phytophthora cactorum* as described by Rosenbaum (Corn. Agr. Exp. Sta. Bull. 363:65-106. 1915.). Later cultures made at the same time and on the same medium, oat agar, from this pear fungus and from *Phytophthora cactorum* obtained from Wheztel in Nov., 1909 (host not given us but possibly ginseng,) grew exactly alike. The pear culture this time developed a little more prominent aerial growth, in which the conidial stage appeared. In cultures we found the oogonia varying from 24-36μ and the oospores from 21-32μ, but the average measurements were for the former 27-32μ and for the latter 24-28μ. The appearance of the oogonia and oospores is shown in Plate LVI, 4.

After determining the identity of the fungus we searched for it on the fallen fruit at the Station grounds. We were surprised to find on picking up the partially rotted pears showing no external fruiting stage that most of these contained mycelium of this fungus. An examination of the most suspicious apples on the ground in our orchard at Mt. Carmel also gave similar re-

sults. However, because of the advanced stage of the rots and their exposure to various animal and fungous invasions, we were not able to separate the *Phytophthora* in pure cultures from either the pears or apples. This experience leads us to believe that the fungus as a fruit rot is more common in this country than reports would indicate; by this we do not mean as a serious rot of fruit on the trees, but as an important rot of the fruit after it falls to the ground. It may be, however, that the unusual moist conditions of last summer were responsible for its development here. In no case on any of the fruit have we found any signs of a fruiting stage, so the identity of the fungus is easily overlooked.

We should not be surprised from our experience of 1919 with a variety of root rots, etc., if the fungus is responsible in wet years for more injuries than we now know. Besides the hosts we mention in this Report (apple, corn, peas, pear, sweet-pea, *q. v.*) Rosenbaum, in the reference already cited, gives the hosts for this fungus, reported chiefly from Europe, as follows: *Panax quinquefolium, Cereus giganteus, Melocactus nigrotomentosus, Phyllocactus, Sempervirum, Fagus, Acer, Pinus, Larix, Picea.*

An examination of the literature showed that this fungus already had been reported from this country on apples. Whetzel and Rosenbaum (Phytopath. 6:89. Fe. 1916.) reported it from New York state as found in July, 1915. These apples were on a tree in a garden, but were on branches near the ground. They also stated that it was isolated in the laboratory from apples purchased in the market and give references to its occurrence on both apples and pears in Europe. They report, too, that Osterwalder found both conidia and oospores on rotted fruit in Switzerland, which is different from our experience. Hesler (Bu. Pl. Ind. Pl. Dis. Sur. 2:172. 15S. 1918.) has since reported this trouble on other varieties of apples from New York. Very recently Güssow (Phytopath. 10:50. Ja. 1920.) reported the fungus on pears in Nova Scotia. So far as we have learned, our report is the first on this fruit in the United States. Under the title of "A Phytophthora Rot of Pears and Apples" Wormald (Ann. Appl. Biol. 6:89-100. D. 1919.) has very recently reported this same disease from England and given a detailed account of it including inoculation experiments and references to literature.

We have tried no inoculation experiments yet with the cultures obtained from the pear on either apples or pears. However from this same culture we had tried to infect 20 kinds of seedlings of herbaceous plants to prove its connection with the root rots that have been reported on certain of these. The results are partially given elsewhere under a few of these hosts.

Winter Injury Swellings. A trouble, similar to that shown on apple-twigs in Plate XXXV, b, was found on pears by the Stamford Quality Seed Store in March and by Miss Daisy Ineson from Ansonia in April, 1920. The swellings on the small twigs were usually at the end of the preceding year's growth and often at the base of a dead twig or where one had been. They were about twice the normal diameter of the twig and usually less than an inch long. Cross sections showed the swelling due to increase of pith cells and to a less extent of bark cells, with more or less irregular arrangement of tissues which were somewhat blackened.

The similarity of these enlargements to those described by Hedgecock on apples, *loc. cit.,* due to the crown gall organism, led us to believe at first that these had similar origin. Specimens were sent to Dr. Smith who said that they were not so caused and suggested winter injury. Inoculations made by Dr. McCormick on geranium stems with fragments of the injured tissues failed to produce any suspicious growth although similar inoculations made at the same time with cultures of the crown gall, *Pseudomonas,* were quite successful. This leads us to conclude that winter injury, killing the young growth of the year and slightly injuring that of the preceding year, caused the latter to make a morbid growth resulting in these enlargements.

Pine, *Pinus* sps.

Black Rot, *Sphaeropsis Malorum* Berk. This is a common fungus that causes more or less injury on apple twigs and leaves. We found it on the leaves of *Pinus austriaca,* collected at Black Point, Niantic, and mentioned later under winter injury of buds. It seemed there to be a saprophyte, or at best only a weak parasite, the trouble being originally due to winter injury. Hesler (Corn. Agr. Exp. Sta. Bull. 379:98. 1916.) gives white

pine as one of the hosts of this stage of the fungus whose mature form he finds to be *Physalospora Cydoniae* Arn.

Lightning Injury. Plate XLIV, b. In September, 1917, the writer with State Forester Filley inspected a white pine tree at Cornwall that had been struck by lightning about a month previously. It was a beautiful tall specimen standing by itself on a hillside. The bolt had made an evident crack in the bark from about two thirds the way up, where the branches began, to the ground forty feet below. Except for this splitting and a slight shattering of the bark, as shown in the photograph taken by Mr. Filley, and a few broken branches, there was no evident injury to the tree. Even the foliage on the broken-off branches was still green. The injury was therefore mechanical and not fatal to the cambium, etc., as in the cases of lightning injury to grape and tobacco mentioned elsewhere in this report.

Mice Girdle. We saw serious injury to a young plantation of white pine on a low spot in the American Optical Co.'s land at Union in 1918, and had previously received specimens from Watertown and elsewhere. During the winter of 1919-20, mice were also said to have seriously girdled Scotch pine in some plantations. See Mice Girdle under Apple.

Snow Bend. Plate XLIV, c. In the younger white pine plantations in the vicinity of Norfolk, after winters of heavy snow fall, the tops of the pines have been so long bent over from the weight of snow that the injury causes more or less permanent bends, as shown in the illustration.

Winter (Bark) Injury. Occasionally on the sunny side of white pine trees, there are seen more or less extended reddish brown areas, in strong contrast with the greenish color of the healthy bark. Cutting these with a knife shows that the tissues are dead, at least part way to the wood. As fruiting bodies are not seen in these areas and as cultures from their tissues have yielded no fungous growth, they appear to be merely local winter cankers. Often on older stems, where the tissues are changing from the smooth to the rough bark type, numerous small spots of similar color are seen but these do not usually reach in deep enough to cause particular injury.

Winter (Bud) Injury. Plate XLV, c. The writer, with Mr. Filley, during the summer of 1918 and twice since, made examina-

tions of injured Austrian pines near the shore in two places. The first called to our attention was on Black Point, near Niantic at the summer residence of Mr. A. H. Mosle; the second was at the residence of Dr. Winfield Ayres at Shippan Point, near Stamford. In both cases the trees were close to the shore and exposed to the severe winter storms. The trouble showed prominently the following summer when many of the tips of the branches failed to grow or their buds opened and developed only weakly, often dying later, as shown in the illustration. In late summer these injured and dead tips are in strong contrast with the healthy ones and are scattered more or less over the trees. The leaves at the tip of the Austrian pine branches form in winter a cup in which frozen spray could be easily held, thereby offering excellent opportunity for winter injury of the buds and adjacent tissues.

A search revealed no suspicious insects as possible cause, and the only fungus found, and that sparingly on the oldest injured buds, was the black rot, *Sphaeropsis Malorum,* previously mentioned. The Austrian pine does not seem quite hardy for such exposed places so that each winter some buds are injured but that of 1917-18, being exceptionally severe, caused an unusual amount of injury. One of the owners was inclined to think the trouble a contagious disease, but we have seen somewhat similar injury to unhardy pines in the state plantations at Rainbow. We have never found this trouble inland on Austrian pines, but specimens were sent us from Watch Hill, R. I., also on the Sound, in 1919, so we have no doubt as to its winter injury nature.

Witches' Brooms. We have seen two types of witches' brooms, illustrated here, on pines. On the white pine the broom took a bushy shape due to numerous small branches developing equal growth, with the leaves compactly massed together. (Plate XLVI, a.) The other, XLV, b, was on a branch of Scotch pine in a plantation at Union, where the abnormal growth was more elongated. As this had numerous, stunted, small branches along the sides, it possibly in time would have developed similarly to the other, which was evidently older. No cause was found for either trouble, though winter injury might offer a plausible explanation in the absence of any other.

Yellow Stem-Spot. Plate XLV, a. On the young branches of

white pine one or two seasons old, there frequently develop, especially in the vicinity of Norfolk, evident golden or yellow spots on the green bark. These spots are usually about a quarter to a third of an inch in diameter and very frequently center from the base of a leaf bundle whose leaves may also be yellowed at their base and shorter than normal. As these spots resemble so nearly, in color, the blister-rust infection spots on the leaves and occur most conspicuously in a region where blister-rust had escaped into the woods, we thought that they might be the first signs of stem infection by this fungus. Continued search of microscopic sections made through such spots, however, has uniformly failed to show any evidence of mycelium. The next suspicious agent was the spittle bug, as this insect was quite abundant on these young twigs in that vicinity, but as yet no definite connection between the two has been shown. Injury by bending is said to cause similar spots.

Pine, Umbrella, *Sciadopitys verticillata.*

Black Scurf, *Rhizoctonia Solani* Kühn. The mycelium of this fungus was found by entomological inspector Zappe creeping abundantly over the stems of young Japanese umbrella pines just imported from Holland. It had not caused much injury however. Packing the plants closely in a closed case no doubt favored its development.

Pleroma, *Pleroma splendens.*

Intumescence. Plate XLVI, b. This unusual trouble on the leaves of a Pleroma plant was sent to the Station in Oct., 1916, by Dr. F. H. Williams of Bristol. Although he had owned the plant for twenty years, this malady had only shown during the last three or four. During the winters the plant was kept in a window on an enclosed stoop, steam heated, and in the summers was planted outdoors, usually in shade. As the white fly had troubled it the last winter, it was cut back to the roots when taken out doors and planted in the sun. It made a fair new growth outdoors, with no trouble showing, and when transferred indoors continued to grow rapidly with the intumescences appearing in the leaves. Later formed leaves, however, did not show the trouble.

The very small pimply outbreaks, faintly shown in the illustration because of the hairy covering, were confined chiefly to

the upper surface of the leaves and were usually thickly placed over the whole surface. They resembled somewhat extraneous deposits since when wet they had a gelatinous-like appearance. Sections through the leaves showed that they were formed by a morbid growth of unusually elongated cells. We think the trouble was due to unusual turgor brought about in the developing leaves from excessive water supplied by the roots. Cutting back the plants severely, planting them in the sun outdoors, and then transferring them to the partially shaded stoop, with the presence of numerous hairs on the leaves to lessen transpiration, all were factors in upsetting the proper balance between water supplied by the roots and its transpiration from the leaves.

Several American papers have appeared, most of them recently, on intumescence of leaves. Von Schrenk (Mo. Bot. Gard. Rep. 16: 125-48. 1905.) describes and figures intumescences on cauliflower leaves due to various copper sprays. Smith (Journ. Agr. Res. 8: 165-86. 1917.) similarly treats of intumescence on this same host produced by various chemical vapors. Harvey (*Ibid.* 15: 83-111. 1918.) relates where they were caused on cabbage by frost. Wolf (*Ibid.* 13: 253-9. 1918.) gives injury from wind-blown sand as an ultimate cause of such trouble on cabbage.

Poplar, *Populus* sps.

European Canker, *Dothichiza populea* Sacc. & Briard. Plate XLVII, a. This disease has been well described by Hedgecock and Hunt (Mycol. 8: 300-8. 1916.). It was first called definitely to our attention in Connecticut by F. A. Bartlett (Tree Talk 4: 76. 1917.) from Stamford in 1917. We are not sure, however, that the canker trouble mentioned in our 1903 Report, p. 347, was not due to this fungus. In recent years specimens have been received from Stonington, Hartford, New Canaan and New Haven. It is found in nurseries as well as on private grounds, and in our experience seems to be more or less associated with winter injury. The Lombardy poplar is the most common host here. On smooth bark of smaller branches it forms a brownish dead area with the fruiting stage evident as small erumpent pustules. On older branches or the main trunks quite evident cankers, as shown in the illustration here, may develop. When these girdle the stem the parts beyond die.

Potato, *Solanum tuberosum.*

While not as a rule so serious as the fungous diseases, non-parasitic troubles of the potato are at least more numerous in this state. They are due to a variety of causes but chiefly to unfavorable or unusual weather conditions. A few are caused by other environmental factors; some are constitutional, being inherited from the preceding crop; one or two are somewhat infectious. Regarding the weather conditions, mention should be made of the year 1918, when an unusually large number of these troubles appeared, due in part to the effect of the severe winter of 1917-18 on the stored tubers and in part to the wet-spring, dry-summer weather that followed. In the previous Reports we have discussed briefly a few of these troubles, such as tip-burn, internal brown spot, spray injury, etc., and in the following pages fifteen more are added to this list.

Aerial Tubers. Plate XLVII, b. Occasionally there has been sent to the Station for examination and explanation potato vines producing abnormal swellings on the stems above ground. In such cases usually some injury has occurred on the stem beneath the ground, thereby cutting off the food material manufactured in the leaves from being transferred to the rootstocks where it is stored in the tubers. As a result of injury below, the material is stored in the stem above ground in these unusual aerial tubers. Injury to the stem by the *Rhizoctonia* fungus is one of the common causes of these monstrosities. In both 1916 and 1917 fine examples of aerial potatoes were reported; Plate XLVII, b, shows some of those found on plants in a Yalesville field where the injury was caused by *Rhizoctonia.* Orton (U. S. Dept. Agr. Bull. 64: 33. 1914.) has described a case of aerial tubers on leaf roll plants where there was no injury to the base of the plants. Phloem-necrosis, no doubt, had its influence in this case, as the elaborated sap is carried down the stem through the phloem.

Black Heart. This trouble, as indicated by its name, shows as a blackening of the tissues at the center of the tuber. Often this blackening is accompanied by large cavities. It has only been reported to us once or twice, in recent years, from this state.

Bartholomew (Phytopath. 3: 180-2. 1913.) found it developed on potatoes shipped in heated cars and he was able to produce it in the laboratory "when potatoes taken in April and May from

storage cellars were exposed to a temperature of about 38° to 45°C, in an ordinary drying oven for from eighteen to forty-eight hours."

Stewart and Mix (N. Y. Exp. Sta. Bull. 436: 321-62. 1917.), who also studied the trouble, succeeded in producing it by cutting down the supply of oxygen needed for the slow changes that take place in the dormant tubers. They therefore concluded that the trouble results from improper storage conditions, such as poor ventilation and piling the potatoes too deeply in bins and cars, as well as by too high a storage temperature.

Curly Dwarf. Plate XLVIII, a. As indicated by the name and by the accompanying illustration, this trouble applies to potato plants of a decided dwarfed development, with curling and wrinkling of the foliage. Orton (*loc. cit.*: 37-40. 1914.) writes: "The stem and its branches, the leaf petioles, and even the midribs and veins of the leaves all tend to be shortened in many cases to a very marked extent, and particularly in the upper nodes of the plant, so that the foliage is thickly clustered. Typical curly-dwarf is readily distinguished from leaf-roll by the wrinkled or downward curling of the leaves, the normal color of the foliage and the firmness of the leaves, which do not lack turgidity."

We have occasionally found curly-dwarf plants in potato fields in this state, but do not believe it is as common here as in some potato districts. It is an hereditary trouble transmitted through the tubers. Quanjer (Phytopath. 10: 35-47. 1920.) claims that curly-dwarf is only an extreme case of mosaic.

Frozen Tubers. During the winter of 1917-18, because of its severity, many potatoes in farm storage in this state were frozen. Badly frozen tubers soon rot, so they are of no value. Others only slightly hurt are often put on the market. Such tubers tend to darken, when cut. We believe that some of the unusual troubles, such as spindling sprout, that developed in the potato crops of 1918 were due to potatoes so injured.

Hollow Heart. Plate XLVIII, b. This is a name applied to potatoes that have a conspicuous cavity in their center. Large potatoes, especially those of certain varieties as Dibble's Russet, are more apt to develop such cavities than the smaller tubers. Usually the trouble appears in a season favorable for rapid

growth, especially if dry weather is followed by very wet. The cracking of the fruit in certain varieties of peaches and musk melons is a similar phenomenon in our opinion.

Leaf Roll. Plate XLIX, a. This trouble is distinguished by a decided upward roll of the margins of the leaves, and often is accompanied by more or less color changes. The plants often make a fairly normal growth otherwise. It is easily distinguished from the work of aphids by the upward, instead of the downward, roll of the leaf margins. Leaf roll has been much studied in Europe (See Orton, *loc. cit.*: 18-33.) and there are various opinions concerning it. There seem to be at least two types, one merely a seasonal trouble due to unfavorable weather conditions, as too much wet weather followed by dry, and another that is a constitutional and more serious trouble. Most of the roll we have seen in this state on both potatoes and tomatoes we believe to be of the former type. In 1918, however, in a yard in Westville, we saw what may have been the second type. It was quite evident on Gold Coin, but not on other varieties grown near by. True leaf roll, according to Quanjer, is a phloem-necrosis trouble and is both contagious and pseudo-hereditary.

Mosaic. This chlorosis trouble of potato foliage was first noticed by the writer in this state in the early summer of 1916. Both Green Mountain and Irish Cobblers, the two varieties most commonly grown here, showed the trouble. It was seen again in 1917 in several fields, but probably not so prominently on the whole, as in 1916. In 1918 it was more prominent but in 1919 it was less evident than in any of these years, due apparently to favorable weather conditions for foliage growth. The leaves show a yellow-green mottling and some crinkling of the foliage, something like the mosaic of tobacco but usually not so prominent. As the vines grow older this mottling usually becomes less rather than more prominent. Mosaic tubers from Maine, furnished the writer by the U. S. Dept. of Agr. and planted at Mt. Carmel in 1919, failed to show any more signs of mosaic on their leaves than did the so-called checks from the same source. The former, on the other hand, were a less thrifty strain, as shown by the size of the vines, etc.

We have not noticed that Connecticut potato fields were very materially affected as to vigor or yield of tubers, but in Maine

and some other states where this trouble is more prominent, it is said that mosaic plants give smaller yields. In Bermuda Wortley (Rep. Dir. Agr. 1914 and 1915.) reports this trouble very bad on Bliss Triumph. He found the yield from mosaic tubers to be half that from tubers of mosaic free plants. As a result of his investigations importation of seed stock into this island is regulated to guard against bringing in this trouble from badly infected fields.

Quanjer of Holland, *loc. cit.,* and Schultz *et al.* of the U. S. Dept. of Agr. (Journ. Agr. Res. 17: 247-73. 1919.) have done much work on this disease and their experiments show that it is not only a constitutional trouble carried by the tubers, but it is contagious in the field. The latter investigator found aphids as one of the carriers of the trouble from diseased to healthy plants.

Net Necrosis. Plate XLIX, b. We have previously described in one of our Reports an internal brown spot of potato tubers that is somewhat similar to this. In net necrosis, however, the brownish diseased areas are smaller and more net-like. Neither is caused by fungi and their nature is not well understood. It is thought by some that net necrosis is connected with some of the other troubles described here.

Potash Hunger. In 1917 and 1918 there was some indication that potatoes suffered from lack of potash, especially on certain soils and where manure was not used abundantly. Such plants are said to show more or less bronzing of the foliage and are apt to flop over easily or turn yellow and die prematurely and are subject to early invasion by saprophytic fungi. It is hard to tell, in our opinion, potash hunger from unbalanced fertilization or from the drought injury described here in detail under Wilt and Prematuring, *q. v.*

Premature Sprouts. Plate L, a. Another trouble of potatoes reported as not uncommon in both 1916 and 1917 was the premature sprouting of the tubers before being dug. Usually only occasional hills in the fields showed this trouble, so that the injury was not very great, and the sprouts found were not elongated, being something like those shown in the illustration. However we did see cases in 1917 where these sprouts not only became elongated but appeared above ground and formed foliage.

Sometimes the sprouts merely developed into small secondary tubers. Such are sometimes found on sprouting old tubers in storage.

We are not sure of the cause of this premature sprouting but believe it may be caused by plants receiving a serious set-back, as by drought, before they are fully matured, and then having a favorable period for growth start into activity again. Such conditions we know will cause "knobby" tubers. Knobby tubers are often found in fields where tip-burn or blight has badly injured the vines but still left them vigorous enough to respond to a later favorable growing period.

Rootstock Invaded-Tubers. Plates L, b, LI, a. An occasional injury is found in potato fields where the rootstocks of some other plant penetrate the tubers themselves. Nut grass, *Cyperus* sp., not infrequently causes injury of this kind. The most serious injury of this same nature we have seen was in a field of Mr. Arthur Clark at Orange in 1917 and was caused by quack grass, *Agropyrum repens.* Here the slender rootstocks of the grass, as shown in the illustration, not only bored into many of the tubers, but in some cases went clear through them, coming out at the opposite end and formed a leafy shoot above ground. It is a question whether these penetrating rootstocks receive any nourishment from the potato tubers. The tissues of the two plants evidently form no union, though in some cases, short side sucker-like branches were formed. No noticeable injury of tissues in their vicinity was observed; in fact the rootstocks seemed to force their way through the tubers with no special discoloration of the invaded tissues. Such invaded tubers have no market value.

Russeted Tubers. Plate LI, b. This name is applied to tubers with a thicker or rougher skin. Certain varieties have a more russeted skin than do others, but under certain conditions the skin in the same variety may be rougher than normal. The sample shown here is an unusual or areated russeted type. It came from Maine seed potatoes and probably, as in other cases, was due to some external irritant, like a fertilizer, acting on the skin when quite young, and stimulating it to form an unusual corky growth.

Spindling Sprout. Plate LI, c. The chief characteristic of this trouble is the slender needle-shaped sprouts that appear in

place of the normal lead-pencil thick sprouts. The trouble was not uncommon in 1918 but we saw little of it before or since. This leads to the belief that it is in some way connected with freezing or too cold storage of the tubers in the preceding winter. Spindling sprouts grow into very weak small plants that yield poorly if they survive. One grower in 1918 plowed up his entire field as worthless. Stewart and Sirrine (N. Y. Agr. Exp. Sta. Bull. 399: 133-43. 1915.) have studied this trouble rather carefully, and while they do not know the cause they found home-grown seed developed the trouble much more than northern grown, where the trouble rarely occurs. Excessive heat and drought are given by them as a possible cause.

Wilt and *Prematuring*. Plate LII, a. There appeared suddenly, in 1918, in southern Connecticut an unusual trouble popularly designated as a blight, which was first called to the writer's attention on July 6th in a field that had grown potatoes for three years. In this field a spot had yellowed up and was dying prematurely, and the owner said that he had first noticed the trouble two or three days previously. Later the writer saw many similar fields and received numerous complaints. The trouble seemed to be a complicated one with indications that more than one factor entered into it. However, our general conclusion was that primarily it was not due to fungi but rather to lack of sufficient moisture and food for continued normal plant growth.

The fields visited showed two or three types of the trouble, as follows: 1. A prematuring of the vines in which the stem and leaves gradually turn yellow, the plant often remaining erect, the leaves dropping off or dying, and finally the whole plant succumbing. 2. Plants wilting and flopping over as if the stem had not strength enough to support them. Parts normally green and no particular spotting of the stem. 3. A bronzing and spotting more or less of the stem; plants lopping over somewhat; frequently the stem was soft near the ground so that it was easily pinched together, as if some fungus or borer had been at work.

We carefully examined the stems above and below the ground in the field, and cut many sections of the stems in the laboratory, and while occasionally bacteria and fungous threads were seen which might aid in wilting, and a *Phoma* that possibly might cause rotting, we found no definite association of these particular agencies with the trouble.

The wilt first showed on Irish Cobblers or other early varieties. Irish Cobblers and Green Mountains are the varieties most frequently planted in this State, and are the ones on which the trouble appeared most prominently. Dibble's Russet was the least injured variety seen. We have since learned that it is a variety quite resistant to drought injury.

The time of planting or maturing of the potatoes seemed to have had considerable to do with the appearance of the disease. In other words, the trouble did not develop until the plants had bloomed and were in that stage where the foliage had made its growth and most of its energies were used in the formation of tubers. The trouble quite often was very prominent on Irish Cobblers when Green Mountains beside them did not show it, or on Irish Cobblers when near-by rows of the same variety planted a few days later did not show it. In time, however, both the Green Mountains and the later planted Cobblers did have the trouble when they reached the right stage of maturity. One farmer planted Irish Cobblers and Green Mountains on four different dates, covering a month, and the trouble appeared in the fields and varieties in the order of their planting and maturity, being quite severe on the earliest when just beginning to show up on the latest.

We saw many cases where the trouble showed over a field when the vines under shade trees, especially apples which are apt to be within the field, were still quite green and unaffected. In other cases where the field was quite irregular the vines were always green in the gullies on the lower portions where the earth was more moist and got the wash from the fertilization. Invariably in fields with gravelly knolls the trouble first appeared and showed more prominently in those spots, no matter what the fertilization. In fields insufficiently fertilized, the trouble was most pronounced, especially if only artificial fertilizers were used. Fields that had been heavily manured, or had a complete fertilizer containing potash, did not usually suffer like fields where only a 4-10 fertilizer was used. Fields of poor or leachy soil on which a 4-10 fertilizer was used were seen producing a fairly luxuriant growth under the favorable moist conditions of the spring and early summer, but going down when this fertilizer had been used up or leached out.

The lack of moisture had a very important bearing on this trouble and was also shown by injury to other plants, grass dying, and trees losing their foliage, from the dry hot weather of July 21st to 30th. The potato is more subject to drought injury than any of our cultivated crops, so naturally this was the first to show ill effects. Ordinarily this is shown as tip-burn but in 1918 the injury was not so much of this type as in the prematuring of the foliage.

All these facts led us to the conclusion that lack of moisture and in some cases insufficient plant food of which lack of potash was one of the chief factors, were primarily responsible for most of the troubles, rather than fungi, poor seed, or insects, especially lice, all of which were attributed as the cause.

Radish, *Raphanus sativus.*

Club Root, *Plasmodiophora Brassicae* Wor. This was sent us Sept. 20th, 1917, from Northford by Mr. Burnham and was the first collection on the radish from the state. See Kohlrabi in this Report.

Raspberry, *Rubus* sps.

Orange Rust, *Gymnoconia interstitialis* (Schl.) Lag. (*Puccinia Peckiana* Howe). Plate LII, b. In our 1903 Report under Blackberry, Dewberry and Raspberry we recorded the presence of the I stage (*Caeoma nitens*) of this fungus as occurring on these hosts in Connecticut. The recent work of Kunkel (Bull. Tor. Bot. Club. 43: 559. N. 1916.) however has shown that there are two forms in this country known under the general term *Caeoma nitens.* One of these germinates with a long non-septate germ tube, and the other with a short septate promycelium producing sporidia. Morphologically the spores of the two cannot be distinguished. The first form Kunkel calls the long cycled because it is the I stage (*Caeoma interstitialis* Schl.) of *Gymnoconia interstitialis,* also found in Europe, and the other he calls the short cycled since it apparently reproduces itself and has no connection with any other stage. This latter form he considers to be the true *Caeoma nitens* of Schweinitz. Arthur more recently (Bot. Gaz. LXIII: 501. Je. 1917.) has made this latter form the basis of a new genus and placed it under the species *Kunkelia nitens* (Schw.) Arth. He has made an

arbitrary attempt to determine the specimens of the I stage in his herbarium, placing them with one or the other of these genera (*Gymnoconia* and *Kunkelia*) chiefly according to the part of the country from which they came.

Later still an article by Atkinson (Am. Journ. Bot. 5:79-83. F. 1918.) has appeared, in which he advocates from his investigations and the distribution of the two forms, that the life cycle of *Gymnoconia Peckiana,* as he calls it, is not definitely fixed so that in the warm climate of the south it produces the short cycled form and in the cool climate of the north the long cycled form, and in between sometimes one and sometimes the other according to the temperature conditions of June and July. This interpretation is based largely on the results of infecting raspberries at low temperatures (under bell jar with ice) with spores of the short cycled form from wild dewberry, *Rubus canadensis* as called in our paper, and producing the telial stage of the long cycled form. He thinks that under these cool conditions the short cycled form instead of forming a promycelium with sporidia, really formed the germ tube characteristic of the long cycled form.

For some years we have believed that the orange rust of Connecticut, found most commonly on wild dewberry, was distinct from that we studied previously in Illinois (Ill. Agr. Sta. Bull. 29:273-300. 1893.) since here we never found the III or Gymnoconia stage associated with it. In fact, so far as we know, this stage had not been reported from Connecticut. The past three seasons (1917, '18, '19) in the light of Kunkel's investigations and with help of our assistant Dr. McCormick, we have tested the germination of the I stage obtained from numerous specimens on different hosts from various localities in the state. As a result of these germination tests we have found that both the long and the short cycled forms occur in this state. The classification of these collections according to their germination as given under the different hosts (Gray's 6th edition) is as follows:

Puccinia interstitialis (Schl.) Lag. Long cycled form. On *Rubus hispidus* (wild) 2 tests; *Rubus occidentalis* (cult.) 2 tests; *Rubus strigosus* (cult.) 2 tests; *Rubus villosus* (wild) 1 test; *Rubus* sp. (wild raspberry) 2 tests, (cult. raspberry) 1 test.

Caeoma nitens Schw. Short cycled form. On *Rubus cana-*

densis (wild) 19 tests; *Rubus hispidus* (wild) 1 test; *Rubus villosus* (cult.) 2 tests, (wild) 5 tests; *Rubus* sp. (wild raspberry), 1 test.

From the above it will be seen that out of thirty-eight tests only ten of them were of the long cycled form, and with seven of these we were able later in the season to go back to the same vicinity and collect the III stage on the same hosts and even on the same individuals where known! In three cases we were not able later to look for the III stage. At first we got the impression that the short cycled form only occurred here on blackberries and dewberries and the long cycled only on raspberries. While this seems to be generally true for this state, later results show that no host is infected by only one form, unless it is *Rubus canadensis,* the wild dewberry. From this host all of the 19 tests have yielded the short cycled form, and we have never collected the III stage of Gymnoconia on it. But even here some of the spores in the same cultures with the short cycled have given germ tubes that were of the long cycled type as far as determined without special staining. That *Rubus canadensis* is a possible long cycled host in this state we have further proved by an inoculation experiment as follows: Long cycled spores of the I stage from *Rubus hispidus* from Norfolk were placed June 11th in Petrie dishes on a leaf of *Rubus canadensis.* On July 14th there had developed on this leaf numerous mature sori of the III stage of *Gymnoconia interstitialis* (See Plate LII, b). On the same date I spores of the short cycled form on *Rubus canadensis* from Norfolk, collected at the same time, placed on a leaf of *R. canadensis* in a Petrie dish failed to produce any infection whatever! This we had tried before without results and also several times in the past have tried to infect plants in crocks of *Rubus canadensis* with spores from the same host and have never succeeded.

Our failures to secure infection of *Rubus* sps. with the short cycled form and the fact that it produces sporidia that might easily be blown some distance has led us to consider if it might not be a heteroecious rust having other stages (*Melampsora* for example) on entirely different hosts. So for some years past we have been trying to inoculate various hosts but without results. The hosts and years of inoculation are as follows: In

1914, on *Populus deltoides;* in 1916, on *Populus deltoides, P. grandidentata, P. tremuloides, P. alba?, Salix* sp.; in 1917, on *Salix* sps. (four); in 1918, on *Populus* sp.; in 1919, on *P. deltoides, P. grandidentata, P. tremuloides, Betula populifolia, B. lenta, Salix* sps. (two).

With Atkinson's theory that the same individual host in this locality may one year produce the short cycled form and another year the long cycled, according as the weather at the time is warm or cold, we cannot agree. We have in several cases tested the spores from the same definite locality during different years, and they have always given the same result. We have collected the III stage for three years on the same plants of *Rubus occidentalis* at Birdsey's, East Meriden, and the tests of the I stage there have always been long cycled. Furthermore we tried the germination of both long and short cycled spores several times at ordinary room temperature, and then tried their germination in iced water and got no different results. If temperature determines the type of germination why should collections made in the same vicinity on the same date but from different hosts give different types of germination? Also why in our higher room temperatures did we get both types of germination? We are inclined to interpret Atkinson's successful infection in 1917, where with so-called short cycled spores he produced the III stage on plants kept iced under bell jars as, due first, to the fact that he had favorable conditions for infection, and, second, to the probability that a few of the spores used normally produced germ tubes (long cycle) instead of sporidia (short cycled) as did the majority (just as we have occasionally found to be the case in our cultures from this host, as already mentioned) and it was the former only that produced the infection. In other words we believe that the short cycled form with its sporidia *does not infect the mature leaves but secures infection through the very young perennial* parts as is apparently the case with the sporidia of the III stage. This delays the appearance of the infection until the next year when the I stage is produced from the perennial mycelium. This would account for our failure to infect *Rubus* through the leaves with the short cycled form, and would explain the successful infections with this stage reported by both Atkinson and Kunkel the year after their inoculations were made.

From the observations of our own and those of the various other investigators we therefore come to the following conclusions.

(1) There are two forms (not species or genera) of the formerly so-called *Caeoma nitens* in this country. One of these produces only one spore stage, aecial spores, and can be termed *Caeoma nitens* Schw., and the other produces both aecial and telial spores and can be termed *Gymnoconia interstitialis* (Schl.) Lag.

(2) *Caeoma nitens* through the fusion of the two nuclei in the aecial spores, for some still unknown reason, has become a short cycled form and cuts out the telial stage entirely, but on germinating functions as such, as shown by development of a promycelium and sporidia. *Gymnoconia interstitialis* has aecial spores whose two nuclei do not fuse and so give rise to the ordinary germ tube and eventually to a mycelium with two nuclei to a cell.

(3) Infection from the aecial spores of *Gymnoconia interstitialis* takes place only through the stomates of the leaves and the telial stage results from this. Infection from both the aecial spores of *Caeoma nitens* and the telial spores of *Gymnoconia interstitialis* takes place only by the penetration of the germinating sporidia through very young tissue, usually that of the underground shoots, and this results in a perennial mycelium that the next season gives rise to the aecial stage in the leaves.

(4) *Caeoma nitens* is largely confined to a region south of Connecticut, and *Gymnoconia interstitialis* largely to the region north of this state, but in the intermediary region both forms may occur more or less commonly.

(5) In this intermediary region it is not impossible that the forms are not so definitely fixed but that occasionally on the same host both types of germination of the aecial spores appear; or possibly the same individual host occasionally becomes infected with both forms and both types of aecial spores are therefore produced on it.

(6) However, conclusion (5) does not mean that once the aecial spores on an individual plant, or any plant infected from these, show only the short or the long cycled type of germination that they can be changed to the other type by differences in weather conditions during that or any other season.

Romaine, *Lactuca sativa* var. *Romana.*

Chlorosis. In a private garden in the fall of 1916 at Middlebury, we saw an occasional plant of Romaine or Cos lettuce in which the leaves showed a yellow mottling and crinkling. This, while indicating an unhealthy condition of the plant, was no disadvantage so far as the edibility of the plant was concerned, as such plants were probably less bitter in taste due to less chlorophyll.

Rose, *Rosa* sps.

Powdery Mildew, *Sphaerotheca pannosa* (Wallr.) Lev. In July, 1919, specimens of Dorothy Perkins roses were brought to the Station from New Haven by their owner to learn what caused their failure to open properly. Many that did open made inferior blossoms that frequently died prematurely. An examination showed that the hips were covered, in part or entirely, with a thick whitish felt of the above fungus. This was made up of mycelial threads with few conidiophores, and doing little or no injury. On the inside, however, a less conspicuous mycelial growth, with plenty of conidia, was the cause of the injury to the petals, that prevented their proper maturity, etc. In the writer's garden the same trouble developed similarly but with the perithecia, deeply imbedded in the felty mat, finally appearing. The Dorothy Perkins was injured more than the Crimson Rambler. We have reported this fungus before but not on blossoms causing injury of this nature.

Fasciation. This specimen was found in April, 1918, by G. A. Stack in a yard in Westville. The stem as it started from the ground was about a third of an inch in diameter and only slightly flattened. It gradually flattened toward the top, which was broken off, until it was an inch and a half wide. The fasciation seemed to run off from one side since, for the entire length, one side was slightly marked by its thicker more rounded character until near the end where it was entirely separated as a distinct naturally rounded stem about a quarter of an inch in diameter. This extended for less than a foot but had been cut off here as had the flattened portion so the nature of the tips could not be determined. Stewart (N. Y. Agr. Exp. Sta. Bull. 328: 392. 1910.) describes and figures somewhat similar fasciations of rose which are said to be not uncommon. See Asparagus in this Report for other cases.

Rye, *Secale cereale.*

Scab, *Gibberella Saubinetii* (Mont.) Sacc. The conidial stage of this fungus, which until recently has been known as *Fusarium culmorum,* was found in this state for the first time in two rye fields at Yalesville, in 1918. It occurs in the heads causing all or a part of the spikelets to die prematurely, the fungus showing at the base of these as a pinkish growth. While the disease is bad in the middle west, it does not seem to be at all common or serious here in Connecticut. The same thing occurs on wheat, *q. v.*

Spinach, *Spinacia oleracea.*

Dampening Off, *Pythium deBaryanum* Hess. Mr. H. D. Johnson of Highwood called the writer's attention, late in September, 1919, to a young spinach field of his that had been seriously injured by the plants dampening off irregularly in the rows, making a very uneven stand. The plants had come through the ground during a rather wet period which proved to be especially favorable for the development of the disease since a field planted a short time later did not develop the trouble. The seedlings an inch or so high dropped over, the trouble first showing as a blackish or brownish softening of the tissue just below or above ground. After falling over they wither up in dry weather and soon disappear. Mr. Johnson had never been troubled before in this way and it was the first time we had seen dampening off in a spinach field, although we had seen the disease on other seedlings in seed beds and greenhouses.

An examination of the tissues revealed the presence of an abundant, guttulate, non-septate mycelium of the phycomycetous type, but no very evident spore stage, except possibly temporary sporangia. After the seedlings were left in water for a few days a rather luxuriant growth of mycelium developed around them and in this appeared the temporary sporangia, and finally definite oogonia and oospores. These agreed very well in size and appearance with those grown in artificial cultures recently received from the Department of Agriculture at Washington. Plate LVI.

The oogonia varied from 18-27μ, chiefly 20-25μ, and the oospores from 15-21μ, chiefly 16-18μ. The oogonia and oospore walls remain hyaline and the latter are not very thick, usually 2-2.5μ. It seems characteristic of this fungus to produce

oogonia much more readily in a liquid than in a dry medium, so that a portion of our agar cultures transferred to water in a Petrie dish developed them much more abundantly than before. On oat agar the fungus rapidly develops a very prominent, fluffy, aerial, white growth, with some oogonia and temporary sporangia. The temporary sporangia look much like unfertilized oogonia. On roots of peas and corn (*q. v.*) this same year we found different specimens with larger oospores that we have placed under *Phytophthora cactorum.*

Spruce, Norway, *Picea excelsa.*

Felt Fungus, *Coniophora byssoidea* (Pers.) Fr. Mr. Walden found this fungus on young plants of Norway spruce imported from France in 1918. In the packing cases it had developed a very conspicuous felty growth of the tawny mycelium over the individual stems running up onto them from the soil. Whether it caused any harm was uncertain but probably it was developing merely as a saprophyte under these favorable conditions. Dr. Burt confirmed our determination of the species.

Sumach, *Rhus glabra.*

Fasciation. Near the Station grounds a stem of the common sumach was found in 1919 that from the ground up gradually flattened out until the flattened part was twice the normal width of the stalk and much thinner. The end was bifurcated into short tips curved in opposite directions. Brannon (Bot. Gaz. 58: 518-26. 1914.) describes a fasciation of cottonwood and willows on young sprouts from stumps of trees cut down the year before, and discusses the causes of this and other cases of fasciation. See Asparagus in this Report.

Sweet Pea, *Lathyrus odoratus.*

Root Rot, *Phytophthora cactorum* (Cohn & Leb.) Schroet. In our Report for 1907, p. 359, under Sweet Pea we mentioned *Pythium* and *Rhizoctonia* as causes of dampening off. The specimens discussed there were brought to us in July, 1907, by Mr. Walden of this Station from his garden. A re-examination of them shows that the so-called *Pythium,* whose oogonia with oospores were present in the cortical tissues of the roots, is the same thing that in the present Report we have discussed under

peas and called *Phytophthora cactorum.* The oospores from the sweet pea are figured in Plate LVI, 3, and can be compared with those found on the other hosts reported here.

Root Rot, *Fusarium* sp. As well as the garden pea, the Sweet Pea has similar rots due to *Rhizoctonia, Phytophthora* and *Fusarium,* and the effect produced by all three is much the same, in that the half-grown plants turn yellow, wilt and dry up due to the rotting of the roots and base of the stem. The *Fusarium* specimens reported here were sent from the Stoeckel estate at Norfolk, in June, 1918. The fungus is probably the same species that causes more or less trouble in greenhouses on cuttings, etc.

Sycamore, *Platanus occidentalis.*

Electrical Injury. Trees near trolley lines are sometimes apparently killed by leaks in the feed wires. In the summer of 1918, a sycamore tree along the trolley line in Centerville showed such injury on a single branch which had come in contact with the feed wire where the insulation was worn off. A decided burn showed on the under side of the branch, and the leaves had all died. The insulation on the feed wire was evidently quite poor and for a distance of half a mile small twigs here and there on the street trees could be seen that had recently been killed, apparently when the wet leaves came in contact with the poorly protected wire.

Tobacco, *Nicotiana Tabacum.*

Besides the troubles described here we have run across several more, chiefly of the leaf spotting type, but because of their obscure nature we have omitted consideration of them for the present. All of the troubles discussed, except the first, are of a non-parasitic nature.

Bacterial Soft Rot, *Bacillus carotovorus* Jones. Plate LIII, b. The only place where we have seen this trouble was on W. J. Reeves' tobacco at Windsorville. We first saw it there with Johnson of the Wisconsin Station, in July, 1918, and found it there again in 1919. Only a few plants in the field showed the trouble but these were mostly in the same row or near each other. The disease starts at the lower end of the plant, rotting out the pith so that the stem can easily be crushed with slight pressure though the outside may seem nearly normal. The rot

eventually reaches and invades the veins and tissues of the leaves when they drop down and finally die. Johnson (Wisc. Agr. Exp. Sta. Bull. 237: 27. 1914.) has briefly mentioned this trouble under the designation "hollow stalk." He claims it can be produced by inoculation and we succeeded in so doing by cutting into healthy plants and inserting diseased tissue. Not having worked on the trouble from a bacterial standpoint, we merely assume that it is not different from the ordinary soft rot troubles found here on a variety of plants.

Fire Injury. Occasional tobacco plants under tents are more or less injured by the cloth of the tents catching fire and the burning fragments falling down on the leaves. Sparks from locomotives, cigarettes and incendiarism are causes of such fires. Some growers have supplied watchers to prevent them. See Lightning Injury.

Frost Mottling. Plate LIII, a. A curious case of frost injury to young tobacco plants was called to our attention the latter part of July, 1918, by Mr. Beinhart, the Government tobacco expert, at the tobacco farm of Mr. Eastwood in Somers. The owner noticed the trouble about the first of July, shortly after there had been an unusually late frost in that neighborhood. During the two weeks that had elapsed since first seen by Beinhart and then by both of us, the injury had become less conspicuous according to him. At the latter date the plants still showed considerable spotting and some irregularity of leaves, especially of the lower older ones. The spotting was due to the chlorophyll being killed in spots that were now whitish or white and so in strong contrast with the rest of the normally green tissues. Sometimes these white spots were large areas and sometimes small specks of a mottled arrangement, as shown by the two leaves photographed. Such injury follows light frosts, with possibly moisture on the leaves where their tissues are injured.

Hail Injury. Plate LIV. On August 4, 1917, we visited, with Beinhart and Johnson of the Dept. of Agriculture, the region in East Suffield where a storm on Aug. 2d had caused injury to the tobacco. This storm was rather local, doing great injury to some fields, while other fields near by suffered little. A good many large trees or their branches were blown down by the high wind. Tobacco in the open was more or less blown

over and had to be propped up again. The greatest injury, however, was from hail, which in a streak through the region inflicted great damage to the tobacco in the open, numerous fields of which were largely or entirely ruined; it also caused damage to the tobacco under tents in some cases. This latter damage occurred where the wind was strong enough to carry the cloth from the tents. We saw a tent of ten acres where the wind had whipped the cloth to pieces, bent and blew over much of the tobacco, as shown in the photograph taken by Johnson, while the hail entirely ruined what was not injured by the wind.

The hail injury was very marked on the stems, showing white irregular spots where the stones struck. See photo. These spots were entirely on the side of the stem from which the storm came. The leaves were largely shredded from the stem or beaten off on the ground and cut in irregular shapes. The damage caused to this one tent alone was probably five or six thousand dollars. We have seen tents where half a ton of hail stones tore down the cloth and were piled on the ground so that some of them remained there for twenty-four hours afterwards in warm weather.

Lightning Injury. Plate LV, a. Lightning may cause injury to tobacco in two ways. First, it may strike the field and produce injury in circular spots for a short distance around where it struck. This is apt to occur when the tobacco is young, the electricity following the moist earth comes in contact with the stems where it entirely kills the plant, or produces cankers up the stem and injury to the petioles. It also usually produces a permanent curling or a wilting of the leaves, as shown in the photograph. Some growers think that tobacco does not do well in after years on these spots. In one of our Reports we mentioned such injury, investigated by Stoddard, and in 1916 Beinhart showed us another field where similar injury had occurred. He also told of other cases which he had seen.

The second kind of injury which may be produced by lightning is where it strikes the tents running along the wires supporting the cloth, setting the latter on fire. The heat from the burning cloth, or more especially where the flaming particles fall on the tobacco beneath, may cause considerable injury. Some tent fields are protected by insurance against fire injury. When fire occurs

from lightning or other causes, the men, as soon as the fire is discovered, try to limit its spread by cutting through the cloth with corn knives. We saw a field at Scantic, near Bloomfield, which had been struck by lightning and injury caused to the plants under the small portion of the tent burned over. These plants were not entirely killed but showed brown dead spots on the leaves where the heat had been most intense, or the flaming material had touched them.

Potash Hunger. During 1919 we had called to our attention several fields where tobacco was doing poorly for no apparent cause. The leaves often were yellowed and finally spotted and the plants undersized. So far as we could determine the trouble seemed to be a fertilizer difficulty due to insufficiency of potash, of which the tobacco plant is a strong user. We know too little of the trouble, however, to speak positively.

Red Root-Rot. There were also fields or parts of fields, both under tent and in the open, that in 1919 did poorly, evidently because of a reddish rotting of the roots. This trouble did not seem to be caused by fungi. Whether or not the fertilizers used then or in the past had anything to do with the trouble is as yet undetermined, but it appeared to be more a trouble of that kind than of one caused by fungi.

Tulips, *Tulipa* sp.

White Spot. Plate LV, b. In May, 1919, there was called to our attention a curious trouble of tulips of the Darwin type at the Hammer estate at Branford. Each year the trouble was said to appear so that because of it the growing of tulips was being abandoned. Tulips that were picked early and taken into the house did not develop the injury. This showed as numerous small, elliptical, white spots standing out in strong contrast to the variously colored tissues of the petals. At first the spots were greyish or blackish but finally became white with the collapsing of the tissues. The trouble occurred to a much less extent on the leaves.

Jones and Miller (Phytopath. 9: 475-60. 1919.) have recently described a somewhat similar injury on the leaves of tulips, which they call frost necrosis. We were at a loss to account for the injury at Branford, but it is possibly a frost injury, since

there were late frosts that year that did considerable harm to other vegetation. This would scarcely explain, however, its presence each year. Before seeing the Jones article we had about concluded that this trouble was due to smoke injury from a nearby steel reducer. It was only rarely, but at this time of the year, that the smoke was carried over the tulip beds.

Turnip, *Brassica* sps.

TURNIP APHIDS killed by *Empusa Aphidis* Hoffm. In the summer of 1916, lice, *Aphis pseudobrassicae,* were very prevalent on both white and yellow turnips, causing a partial failure of the crop. After most of the harm was done to the turnips, this fungus got started and killed off millions of these lice. Collections were made in September in Mt. Carmel, New Haven and Westville where practically all of the lice on the leaves were killed. The fungus is similar to the species that kills house flies and the brown tail moth larvae.

Umbrella Tree, *Magnolia tripetala.*

Chlorosis. In May, 1916, we received from Southport partially developed leaves of the umbrella tree showing a very marked yellow-green mottling over the whole surface, resembling mosaic of tobacco. As the letter stated that the bark was dead in places and the tree had been ailing since the previous August, it seemed certain that it had been injured in some way, probably winter injury as it is a little out of its range so far north, and that the mottling of the leaves was the result of very poor nutrition on this account.

Wheat, *Triticum vulgare.*

GLUME BLOTCH, *Septoria* sp. We collected this fungus once or twice in our disease survey work in 1918 as a very inconspicuous parasite on the glumes and leaves of wheat.

POWDERY MILDEW, *Erysiphe graminis* D. C. A little of this mildew was found in both 1918 and 1919 in wheat fields. It was too inconspicuous to cause any damage. On rye and barley, however, we have found it causing much more injury and making a more conspicuous growth.

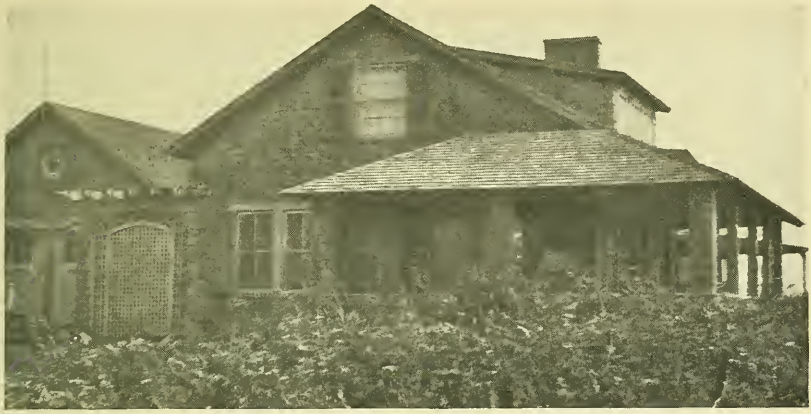
SCAB, *Gibberella Saubinetii* (Mont.) Sacc. Johnson and Haskell (U. S. Dep. Agr. Pl. Dis. Surv. Bull. No. 8, pp. 21-26.

1919.) now give this *Fusarium* fungus the above name and report it very serious in the upper Mississippi valley and eastward, in 1919. We found it first in Connecticut in 1917, and collected it again in 1918, but as on rye, *q. v.*, it seemed to cause little damage in this state.

STINKING SMUT, *Tilletia foetens* (B. & C.) Trel. We also found this smut very sparingly in the grain of wheat in 1918. While very serious in the west, it is a rare fungus here in Connecticut, this being our first collection though we had reported it before in cattle feeds.

Willow, *Salix* sp.

POWDERY MILDEW, *Uncinula salicis* (D. C.) Wint. This powdery mildew occurs more or less commonly on the upper surface of the leaves of certain basket willows at the Station's farm at Mt. Carmel.



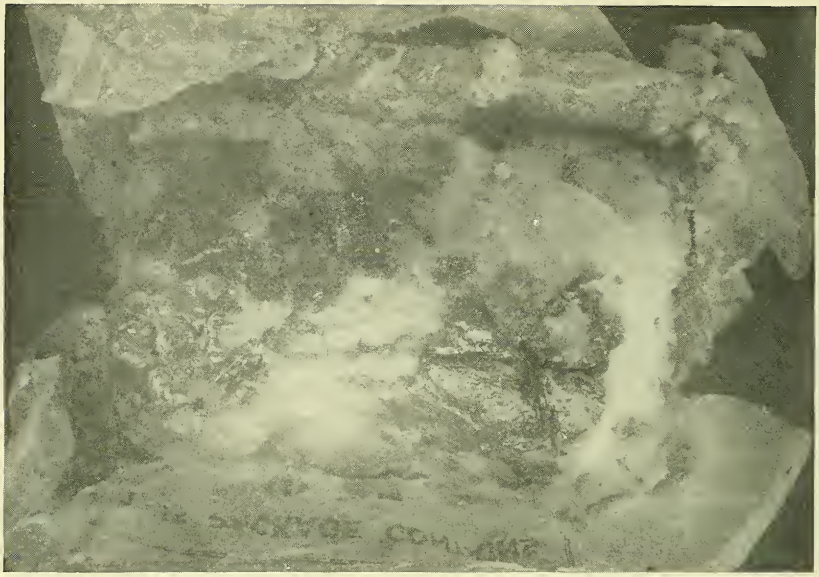
a. General View of Invaded House.

b. Rotten Condition of Living Room Floor.

c. Luxuriant Growth of Fungus on Underside of Boards, etc.

DRY ROT FUNGUS, *Merulius lacrymans,* p. 398.

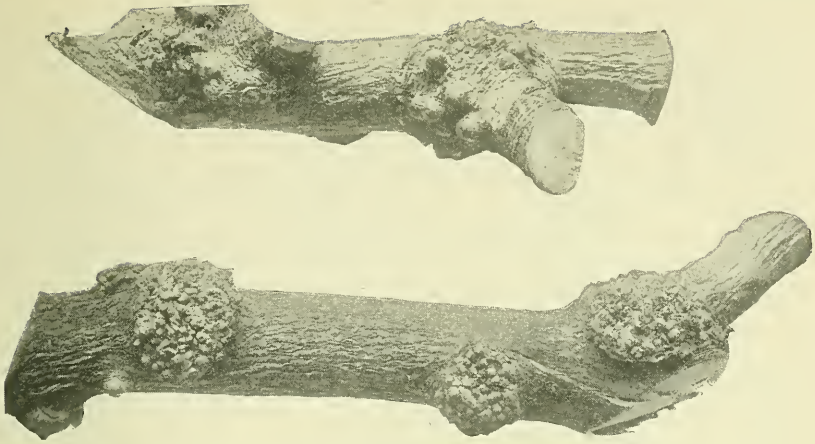
PLATE XXXIV.



a. Mold of Unsalted Package Butter, p. 400.

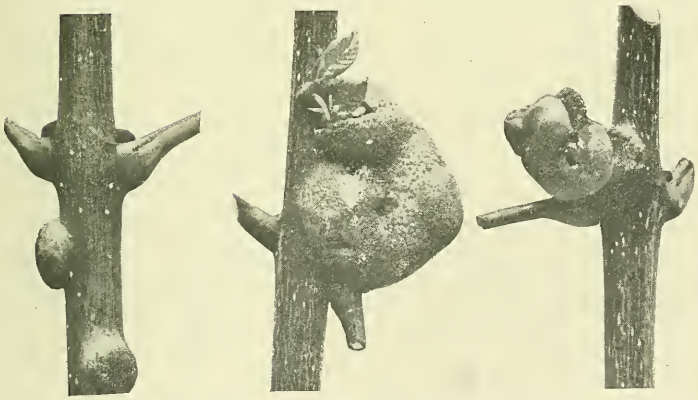
b. Bacterial Fruit Spot, p. 404.

TROUBLES OF BUTTER AND APPLE.



a. Aerial Crown Gall, p. 408.

b. Malformed Twigs, p. 409.



c. Rust causing Swellings in Ash Twigs, p. 414.

TROUBLES OF APPLE AND ASH.

PLATE XXXVI.

a. Fasciation, p. 415.

b. Black Leg of Cabbage, p. 420.

c. Bacterial Wilt of Beans, p. 417.

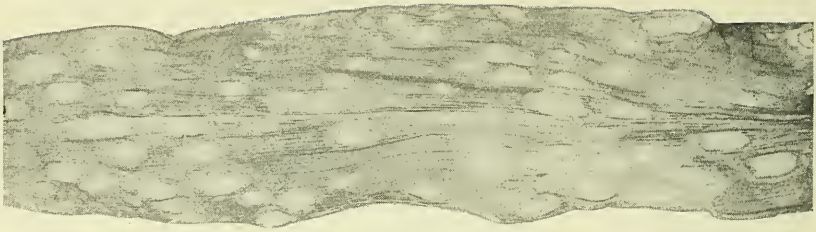
TROUBLES OF ASPARAGUS, BEANS, CABBAGE.

a. Soft Rot of Chinese Cabbage, p. 422.

b. Healthy and Crinkled Celery Leaves, p. 424.

TROUBLES OF CHINESE CABBAGE AND CELERY.

PLATE XXXVIII.

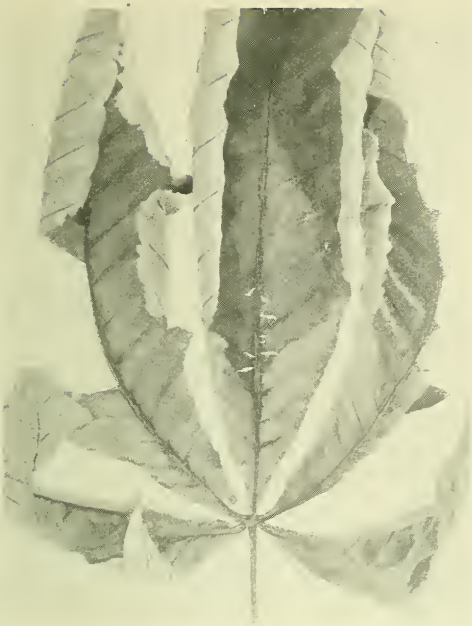


a. Pellucid Spot Disease of Corn, p. 430.

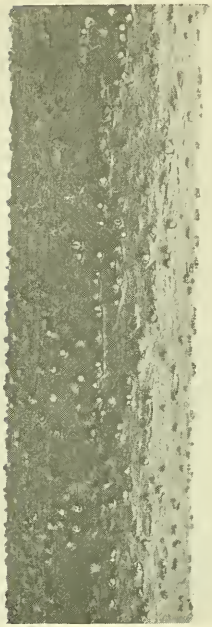
b. Connate Fomes of Hickory, p. 440.

c. Witches' Broom of Hickory, p. 440.

TROUBLES OF CORN AND HICKORY.



a. Anthracnose, p. 441.



b. Red Canker, p. 442.

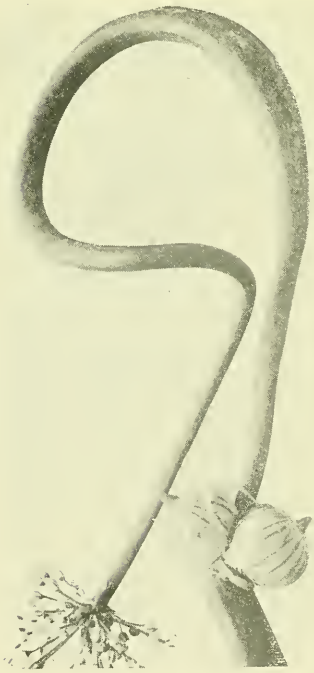
c. Club Root, p. 443.

d. Sulphury Polypore, p. 445.

TROUBLES OF HORSECHESTNUT, KOHLRABI, OAK.

PLATE XL.

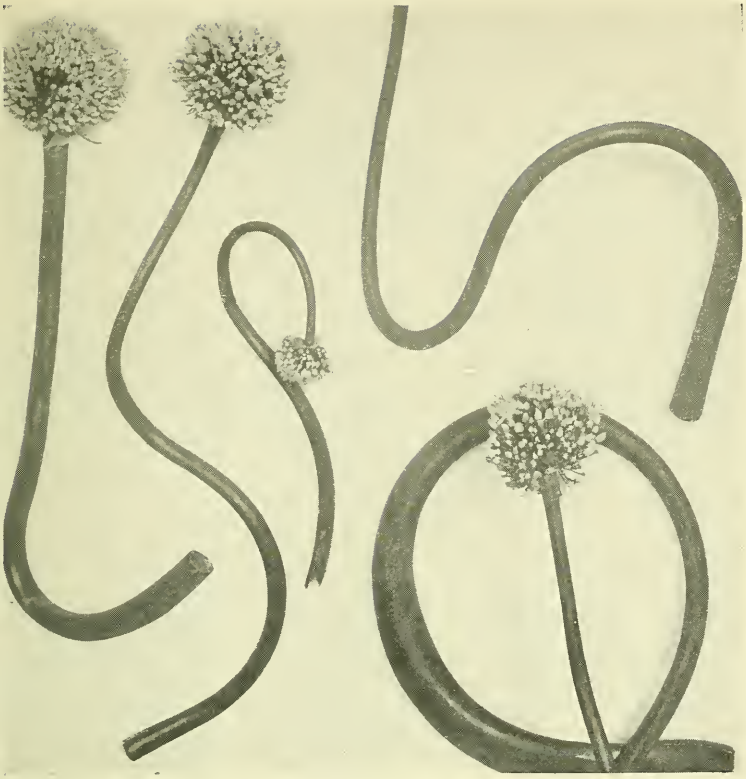
a. Bastard and Normal (central) Onion Blossoms.



b. Bulblet Head.

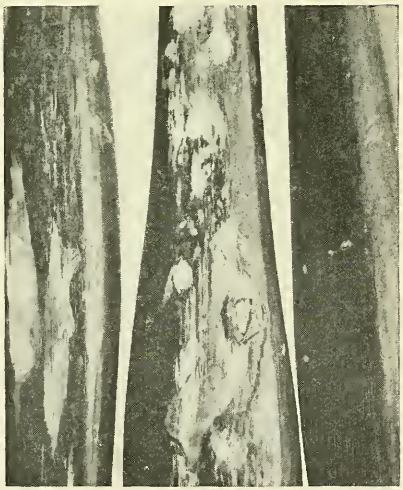
c. Double Head.

TROUBLES OF ONION, 448.



a. Goose Neck, p. 448.

b. Elongated Spathe, p. 448.



c. Hail Injury, p. 449.

TROUBLES OF ONION.

PLATE XLII.

a. Normal and Blasted Heads, p. 447.

b. White Ring, p. 449.

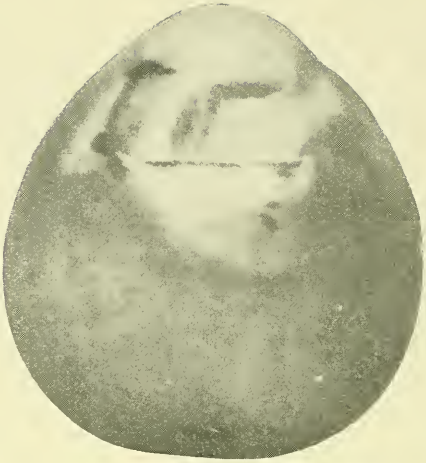
TROUBLES OF ONION.

a. Die Back, p. 454.

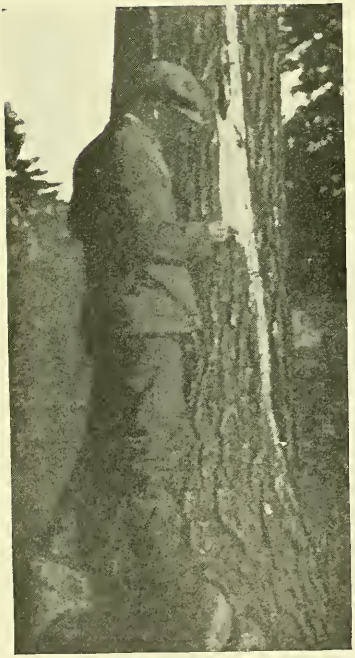
b. Winter Injured Orchard, p. 454.

TROUBLES OF PEACH.

PLATE XLIV.



a. Downy Mildew Rot, p. 454.



b. Lightning Injury, p. 458.

c. Snow Bend, p. 458.

TROUBLES OF PEAR AND WHITE PINE.

a. Yellow Spot, p. 459.

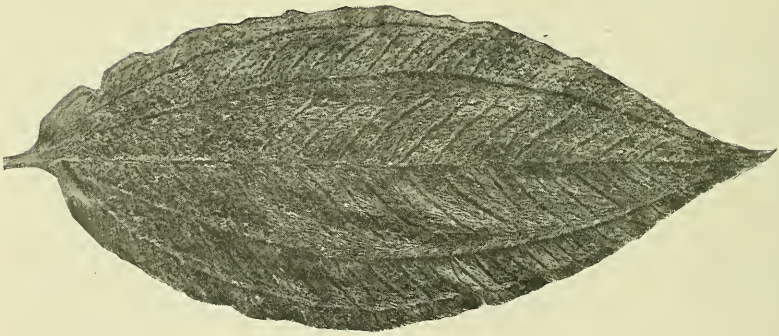
b. Witches' Broom, p. 459.

c. Winter Injury of Buds, p. 458.

TROUBLES OF PINES (a. White, b. Scotch, c. Austrian).

PLATE XLVI.

a. Witches' Broom, p. 459.



b. Intumescence, p. 460.

TROUBLES OF WHITE PINE AND PLEUROMA.

a. European Canker, p. 461.

b. Aerial Tubers, p. 462.

TROUBLES OF POPLAR AND POTATO.

PLATE XLVIII.

a. Normal and Curly Dwarf Vines, p. 463.

b. Hollow Heart, p. 463.

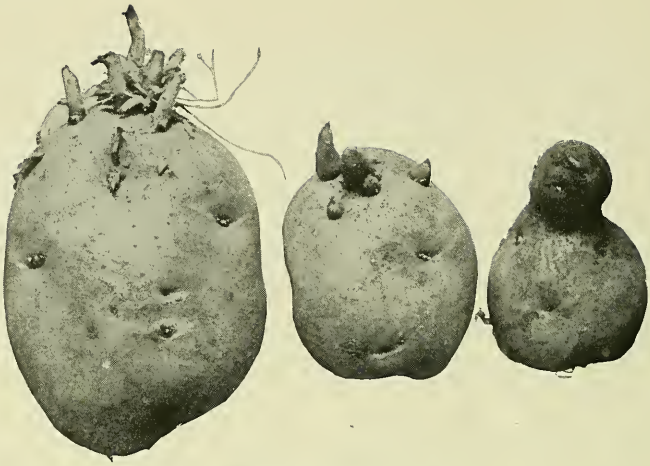
TROUBLES OF POTATO.

a. Leaf Roll, p. 464.

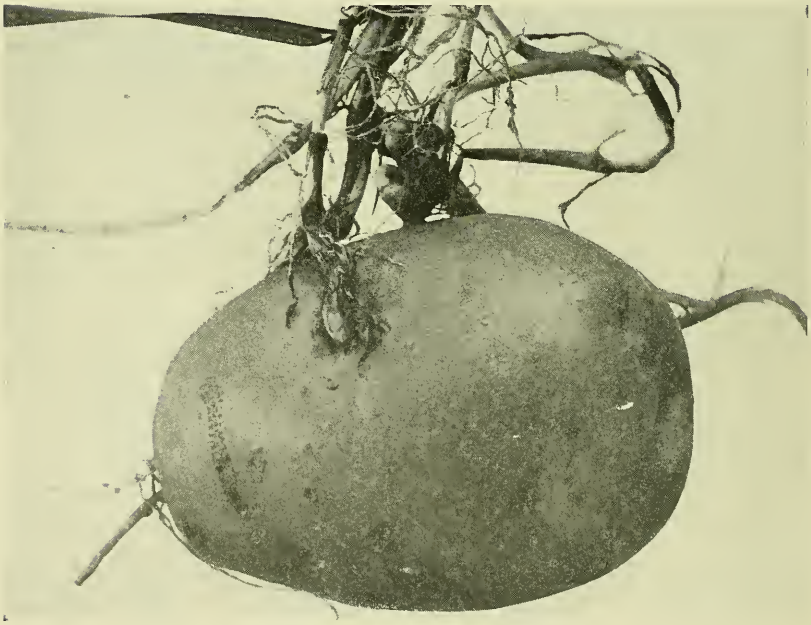
b. Net Necrosis, p. 465.

TROUBLES OF POTATO.

PLATE L.



a. Premature Sprouts, p. 465.

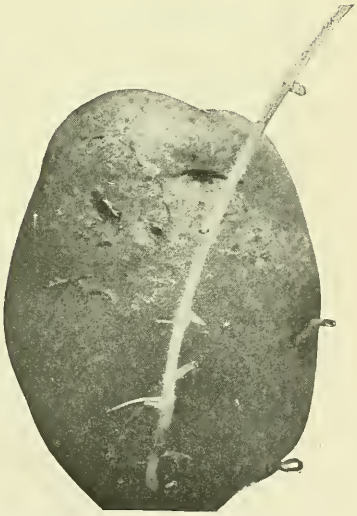


b. Rootstock Invaded-Tubers, p. 466.

TROUBLES OF POTATO.

a. Section through Rootstock Invaded-Tuber.

b. Russeted Tuber.

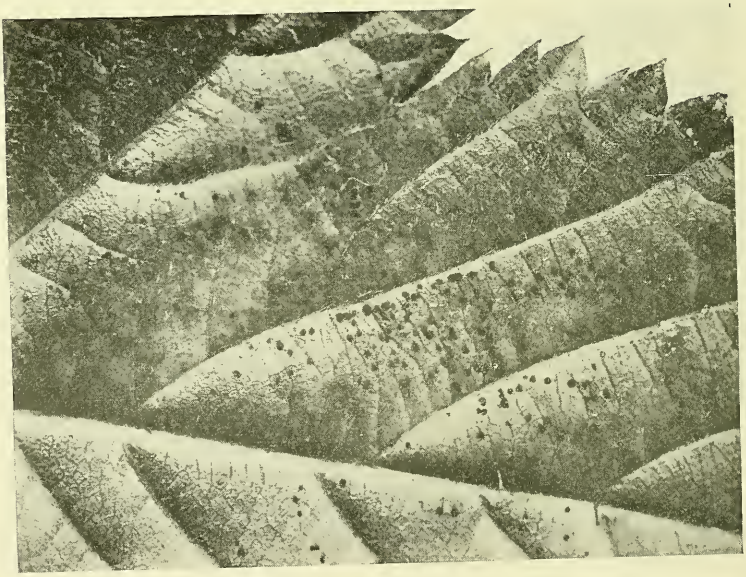


c. Spindle Sprout.

TROUBLES OF POTATOES, p. 466.

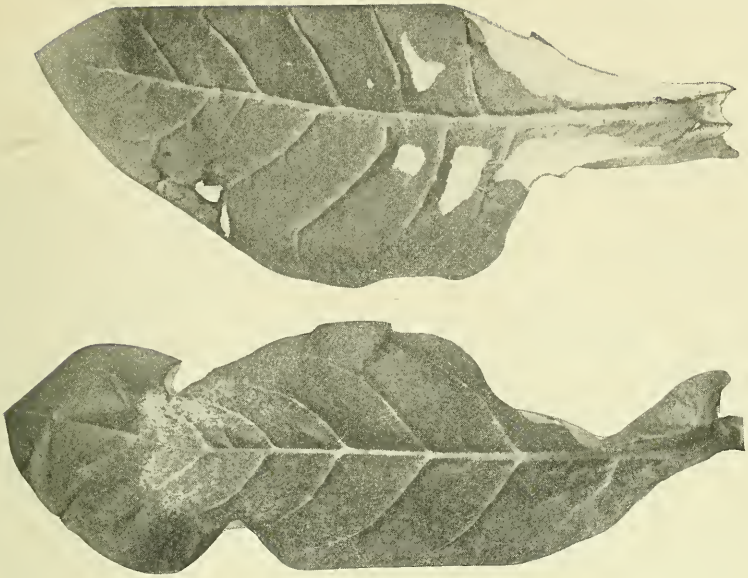
PLATE LII.

a. Wilt of Potato in Center Row, p. 467.



b. III Stage of Rust, p. 469.

TROUBLES OF POTATO AND RUBUS.



a. Frost Mottling, p. 478.

b. Bacterial Soft Rot, p. 477.

TROUBLES OF TOBACCO.

PLATE LIV.

a. Tent and Tobacco Destroyed by Wind and Hail.

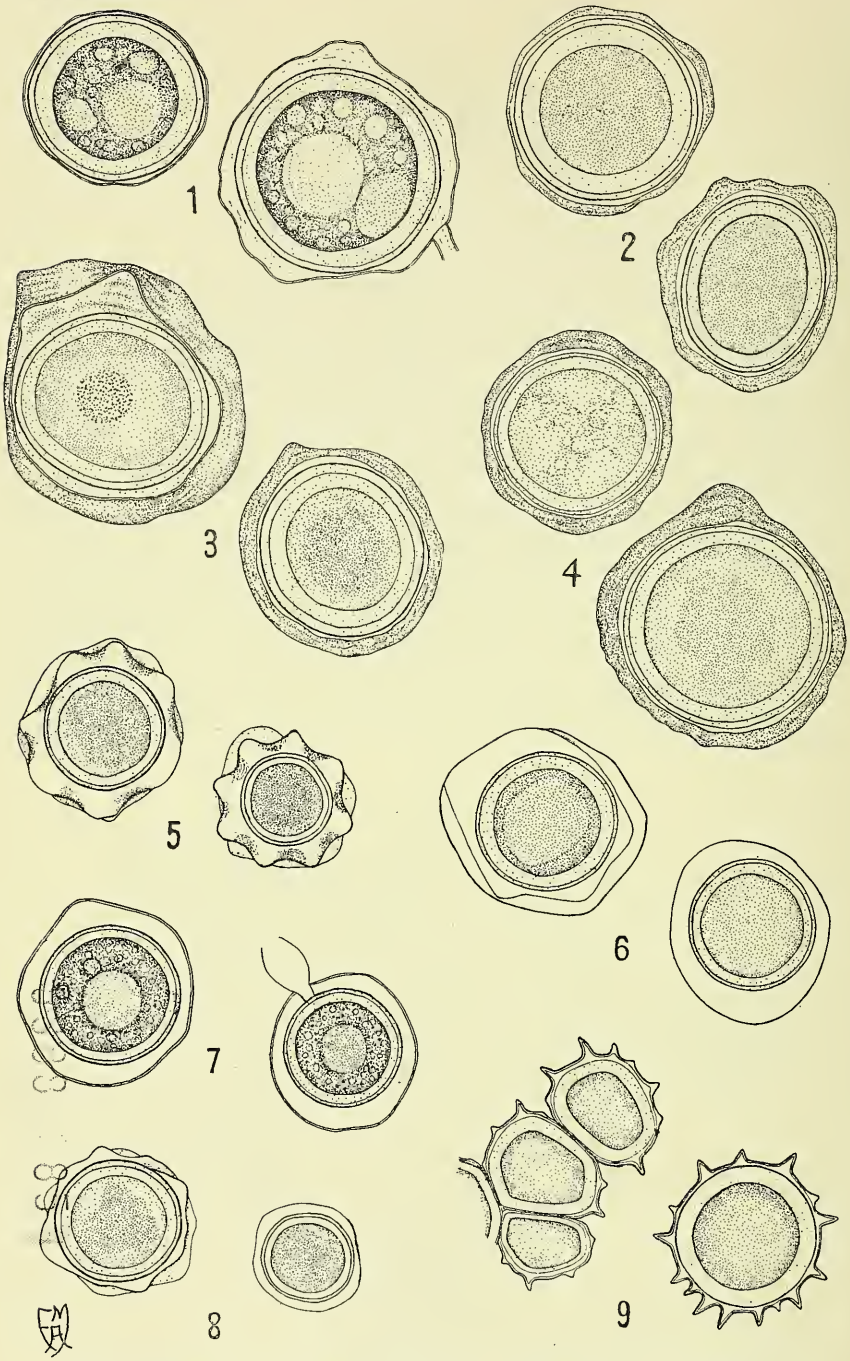
b. Showing Laceration and White Spots.

HAIL INJURY OF TOBACCO, p. 478.

a. Lightning Injury, p. 479.

b. White Spot, p. 480.

TROUBLES OF TOBACCO AND TULIP.



1-4, *Phytophthora cactorum:* 1, From Corn Roots, p. 428; 2, From Pea Roots, p. 452; 3, From Sweet Pea Roots, p. 476; 4, In Artificial Cultures from Pear, p. 454. 5-8, *Pythium deBaryanum:* 5, From Celery Roots, p. 423; 6, From Spinach Seedlings, p. 475; 7, In Artificial Test Tube Culture and, 8, in van Tieghem Cell Culture Drying Out, p. 452. 9, *Pythium hydnosporum,* From Grape Berries, p. 436.

OOSPORES AND OOGONIA OF PHYTOPHTHORA AND PYTHIUM.