# FUNGUS DISEASES

OF

# CITRUS TREES IN AUSTRALIA,

## AND THEIR TREATMENT;

WITH TWELVE COLOURED PLATES AND 186 FIGURES.

BY

D. McALPINE,
GOVERNMENT VEGETABLE PATHOLOGIST.


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DEPARTMENT OF AGRICULTURE, VICTORIA.

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NOVEMBER, 1899.

By Authority:
ROBT. S. BRAIN, GOVERNMENT PRINTER, MELBOURNE.
3316.

# CONTENTS.



## ERRATA.

On page 73, in the fourth line from bottom, for "Native Lemon" read "wild" or "rough" lemon; and on bottom line, after "native," read "as well as imported." The "wild" lemon is believed to be a hybrid.

# CONTENTS.

PART II.—TECHNICAL DESCRIPTIONS OF THE VARIOUS FUNGI FOUND UPON CITRUS TREES IN AUSTRALIA.

# INTRODUCTION.

For several years past I have been investigating at odd times the diseases of citrus trees due to fungi, and the results are now brought together for the benefit of growers. Citrus-culture is with us as yet in its infancy, but from the profitable nature of the crop and the supply falling so far short of the demand, it is almost certain that in suitable localities there will soon be extensive planting.

I find from the Agricultural Statistics of Victoria for 1896–7 that only 32 acres were under oranges and 107 under lemons outside of Mildura, which had 369 acres of the former and 445 of the latter, while in 1897–8 there were 43,261 orange and 58,522 lemon trees in the colony as against 27,835 of the former and 35,710 of the latter in Mildura.

We are just beginning to learn how well adapted are many parts of the colony for the growth of citrus fruits and how mistaken was the idea that they could only be profitably grown in a limited area around Sydney, whereas they are now grown more or less extensively in all the colonies and in localities formerly deemed quite unsuitable.

It is a wise policy to provide for our own requirements if possible, and there is no reason, as far as soil and climate are concerned, why we should import such fruits much longer. At the present time we are being inundated with lemons from Italy, and this shows that a ready market awaits the successful grower. Not only is money expended in purchasing products which might be locally grown, but there is a danger of importing diseases which might seriously affect a young and rising industry.

The Secretary for Trade and Customs has kindly furnished me with a return (Appendix 3) in which it is shown that during 1898 there were imported from Italy alone oranges and lemons to the value of £2,834 and £8,027 respectively, while if we take the value of all the oranges and lemons imported it is £50,614 and £11,884 respectively, or a total of £62,498 during one year.

It is interesting to note that the most hopeful view is taken by those already in the business.

Mr. W. S. Williams, one of the most successful lemon-growers in the Doncaster district, propounded the question—"Can Australasia supply its own requirements in citrus fruits?" at the conference of Australasian fruit-growers held in New Zealand in 1896, and his answer was—"In my opinion, yes, and a great deal more; as, if the system of gathering and storing was adopted, there would be a constant supply and no glut. The fruit that is wasted in winter when there is no demand for it could be kept to meet the demand commencing in November and continuing on into May. Prices would be better regulated, and our Mediterranean friends would have to find fresh markets. It is only a question of a very short time, as there is any amount of suitable land for lemon-growing in Victoria, and more in New South Wales, and then Queensland, the Australian home of the citrus family. Then there is South and Western Australia and New Zealand. Altogether we could supply the half of Europe and have plenty left for ourselves." With such a prospect and the certainty of a much larger area being cultivated, there arises the necessity for spreading information, not only as to the best methods of culture, but how to guard against the various pests which infest every part of such trees from the roots to the fruits. Until a more general work is issued dealing with the various fungus diseases of cultivated plants, it seems to me desirable to select some of the more important economic plants and show to those already engaged in their culture, as well as those about to enter upon it, the fungus enemies with which they have to contend and the best known means of combating them.

I have already dealt with the grape vine,* and described in more or less detail the 23 species of fungi added to the fourteen previously met with in Australia, and shown how they may be kept in check. Then "The Fungi on the Wheat Plant in Australia"† have also been recorded, there being seventeen species already known on Australian wheats. And now the fungi which infest citrus trees are here treated. It will be observed that I have not confined myself to Victorian forms, but have included Australian, because there is such constant communication between the different colonies that the presence of disease in one cannot be ignored by the others; but this is a very different matter from recording

* Additions to the Fungi on the Vine in Australia (with 80 Figures), 54 pp., 1898, Government Printer, Melbourne.

† *Agricultural Gazette*, New South Wales, September, 1898.

diseases indiscriminately which may happen to occur on the same plant in Europe and America. While every precaution should be taken to prevent the introduction of new diseases, I wish to protest against the habit of some of crediting us with diseases which have not yet reached our shores. The fungi here enumerated have all been personally determined, so that we know what is already in our midst and what we have to guard against.

Up to 1898 there were only four fungi which had been scientifically determined as occurring on orange and lemon trees in Australia, and of which descriptions were published, viz., *Capnodium citricolum*, or Sooty Mould; *Corticium nudum*, or Naked Corticium; *Gloeosporium citricolum*, or Leaf Gloeosporium; and *Gloeosporium citri*, or Stem Gloeosporium. A number of other diseases were more or less carefully diagnosed, but the name and nature of the fungi causing them were not known, and consequently an important factor in the rational treatment of these diseases was still wanting.

In the present report there are 82 species of fungi recorded, along with their technical descriptions, 78 being thus added, and 51 of these are new to science. I have carefully distinguished between those which are *parasites*, preying upon the still living tissue, and those which are *saprophytes*, living upon dead portions, destroyed from some other cause. It is not always easy to decide between the two, as some fungi can adopt both modes of life according to circumstances; and between the strictly parasitic and strictly saprophytic, there are many which occupy an intermediate position.

1. True saprophytes are such as live during the whole course of their existence on dead substances, and not on living tissue, and consequently do not cause disease in plants.

2. Hemi-saprophytes are such as are able to pass through their whole development as saprophytes, but may also live in a purely parasitic manner under certain circumstances. Thus the root-rot of raspberries is caused by a fungus (*Hypholoma fasciculare*), which can also live independently on dead and decaying matter.

3. True parasites are always parasites, such as the rusts.

4. Hemi-parasites are such as go through the whole course of their development as parasites, but may become saprophytes, if need be, during certain stages of their existence. Such parasites are able to live upon humus in the soil.

Some growers are of opinion that all fungi are more or less saprophytic, that they only occur when the plant is diseased from some other cause, but even a slight knowledge of the nature and mode of life of fungi would soon dispel such an idea. Saprophytes, however, may be and often are mistaken for disease-producing fungi, and therefore it becomes necessary to recognise them as such, in order to prevent unnecessary alarm.

Taking the occurrence of fungi on still living and growing parts, as indicating generally their parasitic nature, I have provisionally considered 38 species as more or less parasitic, and of these only the more important from an economic point of view have been treated at length.

If the diseases of citrus trees be regarded from a general stand-point, it is noticeable how large a proportion occur upon the orange and lemon.

In Saccardo's "Sylloge Fungorum" Vol. XII. Part II., Division 1, a Host-index is given containing all fungi with the plants on which they occur up to the end of 1897. On the orange (Citrus aurantium) there are 83 species, and on the lemon (C. limonum) 58 species, six of which are also found upon the orange, so that the latter is infested by the greater number of species. If we compare the 82 Australian species as to their distribution on orange and lemon trees respectively, it is found that 25 belong to the former and 31 to the latter along with eighteen common to both. Three occur on the citron, two on the shaddock, and three are parasitic upon scale insects. Saccardo gives the number of fungi on citrus trees, irrespective of their being parasitic or saprophytic, so that a recent notice of this work in an Australian agricultural journal, in which the number of fungi were stated as if all were disease-producers conveyed a false impression.

It is hoped that the plan followed in this publication may enable those interested to recognise the diseases and to treat them with success. In the first part only the more prominent and destructive diseases are dealt with, although it has to be borne in mind that many of those considered less important do a deal of damage in the aggregate, undermining the health of the tree, diminishing the yield of fruit, deteriorating its quality, and rendering it more liable to decay. The description of the disease is given in plain language so that the ordinary grower may recognise it, and the treatment is based upon a knowledge of the exciting cause. I have not had the opportunity of thoroughly testing the best methods of treatment, but such as are given are based upon what we know of the most successful measures employed against similar fungi on closely allied plants, mainly however from the results obtained in Florida by officers of the Division of Vegetable Pathology of the United States Department of Agriculture. With the thoroughness and knowledge characteristic of that department two officers were deputed to study these diseases on the spot, and a laboratory was specially erected for the purpose. The results are given in Bulletin No. 8, entitled "The Principal Diseases of Citrus Fruits in Florida" by Walter T. Swingle and Herbert J. Webber, and Bulletin No. 13, "Sooty Mould of the Orange and its Treatment," by H. J. Webber. I have also given attention to the fungi which aid the grower in destroying those pests which injure his crops, for by pitting nature against herself he is using a powerful ally.

In the second part the minor diseases are dealt with, and technical descriptions are given of the various fungi found upon citrus trees in Australia. This is the most difficult part of the task, involving laborious research and microscopic investigation of fungi which are often unknown to science, and yet it is generally the least appreciated. In the case of insects they are usually of an appreciable size, and appeal to the ordinary observer, but the fungi are often hidden in the tissues of the plant, and only reveal their presence by the mischief they do. Hence all sorts of reasons are assigned as the cause of these mysterious diseases as they are called by people who do not take the trouble to investigate, and who perhaps never handled a microscope in their lives. Of course it is much easier to talk learnedly about sun scald, or frost bite, or chilling at the roots, or speak of die back, black disease, and so on, rather than to probe the matter to the bottom and prove the cause they assign to be the correct one. In speaking of the effects of the researches of De Bary, Tulasne, and others, Professor R. Hartig, of the University of Munich remarks in his "Text Book of the Diseases of Trees"—"The view hitherto held that all fungoid growths appear only as the result of previously existing processes of disease, or as indications of the incipient death of the part of the plant which is attacked was shown to be erroneous." It was then recognised that the tracing of causes is absolutely necessary before remedial measures can be rationally applied, and wherever fungi are concerned they require to be fully studied with all the conditions favouring their development. It is often necessary, likewise, to be certain of the specific fungus causing a disease in order that accurate information may be obtained as to the effect of a particular treatment, otherwise remedies may be and are condemned as useless, when they are really applied to something very different from what was intended.

Having determined that the specific disease is caused by a fungus, it is necessary if possible to fix its position among the 47,000 known species in order to profit by the experience of others, if the fungus and its effects have already been described, or, if new, to understand its relationship with those already known. While the determination of the fungus is the work of the specialist, the intelligent grower may employ some common name expressive of the salient characteristic of the disease, and by which it may be recognised. But since appearances are often deceptive, and very different diseases may be confounded under a common name, I have invariably given the scientific name of the fungus producing the disease along with the common name. This fixes the disease definitely, suggests lines of treatment based upon a knowledge of allied fungi, enables us to profit by the labours of previous investigators, and supplies material for future workers to consolidate and extend the knowledge already possessed. In the Report of the Proceedings of the Eleventh Annual Convention of the Association of American Agricultural Colleges and Experiment Stations (1897) it was recommended that, in speaking of fungi, the technical as well as the common name should always be given at least once in each publication, and this is a recommendation which I heartily indorse.

As already noticed, the fungi are also described which, as far as known, are not the exciting causes of disease, but only appear when decay has already set in. This will at least prevent their being confounded with other fungus pests, which are really serious.

In giving the references to the literature on the various diseases dealt with I have mainly confined myself to those published in Australia, on account of their being probably accessible to the growers, for whom this work is intended. But the various publications of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture may likewise be recommended, as well as Penzig's elaborate work in "Annali di Agricoltura, 1887," together with the accompanying atlas of 58 plates.

While this work is passing through the press, I have received Massee's "Text-book of Plant Diseases caused by Cryptogamic Parasites" (Duckworth and Co., London), which not only treats of citrus diseases but of the principal diseases to which cultivated plants are subject, and it ought to be in the hands of every grower.

I have to thank officers in the other colonies for kindly providing me with any specimens required for investigation, and among these may be mentioned Mr. Bailey, Colonial Botanist, and Mr. Tryon, Government Entomologist, of Queensland ; Mr. Maiden, Government Botanist, of New South Wales ; Mr. W S. Campbell, of the Agricultural Department there ; Messrs. Quinn and Molineux, of South Australia ; and Messrs. Helms and Despeissis, of West Australia.

My assistant, Mr. G. H. Robinson, has supplied the two photo-micrographs reproduced, and Mr. C. C. Brittlebank has made the coloured drawings from nature, which show the principal diseases in such a striking manner that no one can fail to recognise them when met with.

November, 1899.

# PART I.

# GENERAL DESCRIPTION AND TREATMENT OF PRINCIPAL DISEASES.

## PLATE I.

False Melanose (*Cladosporium brunneo-atrum*).

Fig.

1. Orange, showing the brown spots or blotches run together into long irregular lines, and giving the fruit a streaky appearance. (Natural size.)

2. Leaf of Sweet Orange from Florida, attacked by "Melanose." (Natural size.)

PLATE I.

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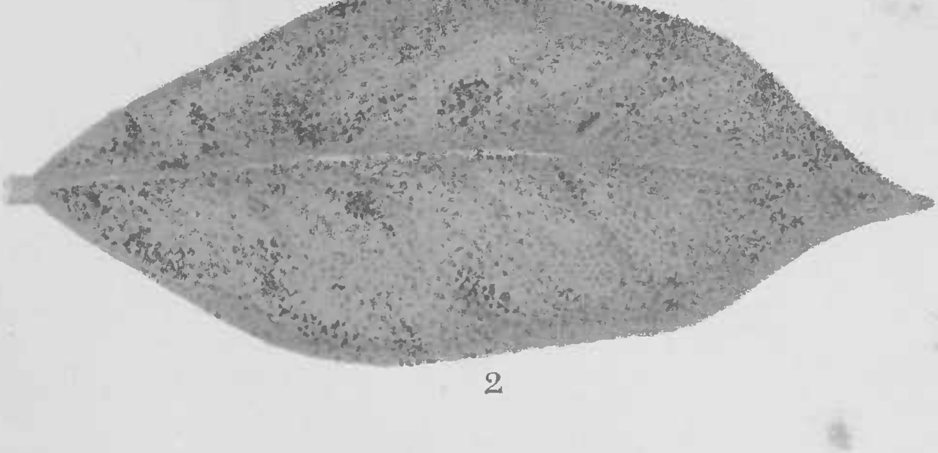

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## FALSE MELANOSE.

(*Cladosporium brunneo-atrum* n. sp.)

This disease is unknown in Victoria, but it occurs in the orange groves of New South Wales to an alarming extent. It was considered by Dr. Cobb to closely resemble a disease in Florida, known as "Melanose," and he named it accordingly, the term being derived from two Greek words meaning "Black Disease."

In Florida, where investigations into the principal diseases of citrus fruits were carried out during three years by Messrs. Swingle and Webber, there was a disease, first noticed in 1892, to which they gave the above name, although the cause of it has not yet been discovered. It was suspected to be due to some vegetable parasite, but the microscope failed to reveal it. It seemed to be contagious, infection only taking place when the tissues were quite young, and the entirely local nature of the disease appeared to point to a parasitic origin. "The strict localization of the disease, so similar to what occurs in scab, again strongly suggests that the disease is caused by some vegetable parasite." No definite organism, however, was found associated with the disease.

Then, in 1897, Dr. Cobb published in the April part of the *Agricultural Gazette* of New South Wales, an account of a prevalent disease on citrus fruits in that colony, which he had little doubt was identical with the Florida disease, so he named it "Melanose," but with a mark of interrogation. He found, however, a fungus associated with this disease, consisting of mycelium and conidia, of which he gives a drawing, but made no attempt to determine its nature. Next, in 1898, Trabut* determined the "Melanose," of mandarins to be caused by a *Septoria*, which he named *Septoria glaucescens.* The interest of this discovery lies in the fact that there is a disease of vines also called "Melanose," and produced by a fungus belonging to the same genus, viz., *Septoria ampelina*, Berk and Curt. The leaves are studded with numerous, small, reddish-brown, or black dry spots, hence the common name. According to a recognized law of naming, this will be the true "Melanose," since it is caused by a similar fungus to that on the vine, and the so-called "Melanose" of citrus fruits being produced by an entirely different fungus will require to be re-named.

I have determined the fungus causing this disease in Australia, which belongs to the scab-producing sort, and it need hardly be pointed out, that the more accurate the determination of the cause, the more likely is a rational method of treatment to be adopted.

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* Comptes Rend. d. séances de l'Acad. d. sc. t. CXXVI. n. 7 (1898).

Mr. W. S. Campbell, of the Agricultural Department of New South Wales, kindly forwarded me, by request, specimens of oranges with this disease, not that I required specimens to be sent, since plenty were available at the wharf, but I wished to make certain that the disease investigated was that known in Sydney by the name of "Melanose." Since this disease is still unknown to me in Victoria, it becomes important to guard against its introduction, as well as to be prepared for it, should it unfortunately appear, and the remarks of the Florida investigators are worth quoting in this connexion. "It appears to be spreading rapidly, however, and may ere long become one of the most common and most injurious diseases. Great care should be taken to prevent the introduction of this malady into California and other orange-growing countries where it is not yet known to occur." And Dr. Cobb points the same moral in the paper referred to when he says—"There is no doubt that Melanose is doing much damage among the orchards around Thornleigh and Parramatta. *Last season oranges spotted over with the disease were to be found in the Sydney market literally by the ton.*" In order to compare the so-called "Melanose" disease of Florida with that similarly named in Australia, Mr. Webber kindly sent me a leaf of sweet orange badly affected. (Plate I., Fig. 2.) Sections of the leaf were made at diseased spots, but no distinct trace of a fungus was found. The cuticle is thickened and together with the epidermal cells is coloured dark brown. Then the sub-epidermal cells multiply at these spots, so that the leaf becomes excessively thickened there and the brown colouration extends to them. On teasing out portions and examining under the microscope, occasionally very slender colourless filaments of a fungus were seen. There is no definite fungus, however, such as is met with in Australian specimens, and for the present, at any rate, the two diseases cannot be regarded as identical. Mr. Webber writing to me, under date, 28th September, 1898, says—"I have made an examination of the affected orange rind which accompanied your letter, and find that in all external characters the disease affecting it is very similar to the so-called Melanose from Florida, described in our Bulletin, No. 8. I made some sections of the rind and had no difficulty in finding the spores of the fungus to which you refer, and in this case there seems to be no doubt that the fungus is the cause of the trouble.

"Both Mr. Swingle and myself have studied the Florida disease at various seasons of the year, but thus far have been unable to find any spores in connexion with it. Several times I have found a colourless mycelium, which I supposed to be the cause of the trouble, but so far I have not been able to secure cultures or find any indication of fructification.

"I enclose herewith specimens of the Florida Melanose so that you can compare the two diseases. It is of course possible that the fungus may bear fruit only under certain conditions, and that we have never made an examination at the right time to find the spores.

"I shall be interested in any results you may obtain in your study of the malady."

While there is not sufficient evidence as to the cause to fix the identity of this disease, still there is a remarkable resemblance in the general appearance with the Australian disease.

*Varieties attacked.*—In Florida the disease seems to attack all citrus fruits, but develops more freely on the shaddock than the others. It occurs not only on the shaddock but likewise on the common sweet orange, sour orange, lemon, and mandarin.

In New South Wales it is only recorded on the sweet orange.

*Parts affected.*—It not only attacks the fruit, but also the leaves and young shoots, and this knowledge will materially affect the methods of dealing with the disease. It is said to develop most freely on young rapidly growing vigorous shoots, and the leaves are much injured by it, so that the general health and vigour of the tree is bound to suffer, apart altogether from the unsightly appearance it gives to the fruit. In New South Wales it also attacks leaves and young twigs as well as fruit.

*Description of Disease.*—It occurs in the form of minute brown spots on the parts named.

On the shoots the spots are at first very small and yellowish, gradually increasing in size and swelling and becoming dark-brown or almost black. The spots are generally roundish, but frequently elliptical and elevated, and it is the elevated spots which are discoloured.

On the leaves the spots are generally round and slightly elevated, and the brown spot on the upper surface of young leaves has usually a corresponding depression on the under surface. The black appearance is more marked on the leaves than the fruit.

On the fruit the disease is very characteristic, and this is the form in which it is most familar to us. The brown spots or blotches are usually run together into long irregular curved lines, giving the fruit a peculiar streaky appearance. (Plate I., Fig 1.) These ultimately become blackish and split up into numerous small areas, like the cracking of mud in drying. The disease known as "Maori" may also occur on the same fruit, but this is caused by a mite, and the brown discoloration, like a Maori's face, is uniform and continuous and not broken up into spots or patches.

*Cause of Disease.*—As already stated, I have determined the fungus causing the disease, and it is a species of *Cladosporium*, various species of which produce "scabbing." This so-called "Melanose" is just a form of scab and must be treated accordingly.

If a small portion from the margin of one of the spots is examined under the microscope, it is found to be penetrated by a perfect net-work of fungus filaments or *hyphae*, bearing the small seed-like bodies or *conidia* in various stages of maturity. The brown, almost chestnut-brown conidia are very characteristic and produced in countless numbers at this season (July) of the year. A complete technical description of this new fungus is given at the end, so that any one with a microscope may satisfy himself as to the exact nature of the fungus, and consequently the definite disease caused by it.

*Treatment.*—Since the disease is caused by a fungus parasite, and infection therefore spread by the innumerable seed-like bodies or conidia produced, it will be necessary to destroy all diseased litter, and see that diseased fruits are removed.

In the Florida orchards experiments were carried out with various fungicides, and it was found that Bordeaux mixture and ammoniacal solution of copper carbonate almost wholly prevented the disease when properly applied.

The following measures may therefore be recommended in addition to careful cultivation, proper manuring, attention to drainage, &c. :—

1. In pruning the trees all diseased branches should be removed, and all the cuttings burned.

2. Spray with either of the above fungicides, and as the usual strength may prove injurious, directions are given at the end as to the quantity of materials to be used. Since the lemon has a more extended flowering period than the orange, it is considered likely that more sprayings will be necessary for it. In the case of the lemon, the first spraying is recommended about a month after the spring blooming, and again about a month later, when flowering has ceased, and the youngest fruits are about the size of a pea.

For the orange the first spraying should be given about two weeks after the flowers have fallen, and the second about a month later.

The Bordeaux mixture should be applied weak, to prevent injury to the trees—at the rate of 6 lbs. copper sulphate, $3\frac{1}{2}$ lbs. lime to 100 gallons of water.

The ammonical copper carbonate solution is not so likely to injure the trees, and may, therefore, be preferred, and used at the rate of 5 ozs. of copper carbonate to 50 gallons of water.

Experiments for the treatment of this disease were carried out by Mr. G. B. Owen, of Castle Hill, New South Wales, in 1896–7. The bed experimented on was eight trees long, and four wide. The trees were fairly large, some 30 years old, and most of them were badly affected, some of them especially so. The whole bed was treated to a dressing of coarse bone-manure, at the rate of about 6 cwt. per acre, and of sulphate of iron 1 lb. to each tree.

The first spraying with Bordeaux mixture was given on 29th October, as soon as the crop was off, and subsequent sprayings on 28th November, 13th January, 11th February, 9th March, and 4th May, or six sprayings in all.

The results, in Mr. Owen's own words, are—"As far as I have been able to find out, there are only two oranges affected with the disease on the whole bed, whereas last year it was hardly possible to find a clean fruit, and the trees, in spite of the droughty season, look better than they have done for years. 3 lbs. sulphate of copper to 40 gallons of water is recommended, as it is perfectly harmless to either young fruit or wood, and after the first year's spraying it is pointed out that one or two sprayings a year may keep the trees clean in future—first, soon after fruit is set; next, when half grown."

Since the Florida disease has been controlled by spraying, it is highly probable that some fungus is concerned, and it may be, as suggested by Webber, that the fungus mainly exists in the vegetative stage there, as is often the case with scab-producing fungi.

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Owen (G. B.)—"Melanose." *Ag. Gaz.*, N.S.W., Vol. VIII., Pt. 9, p. 610 (1897).

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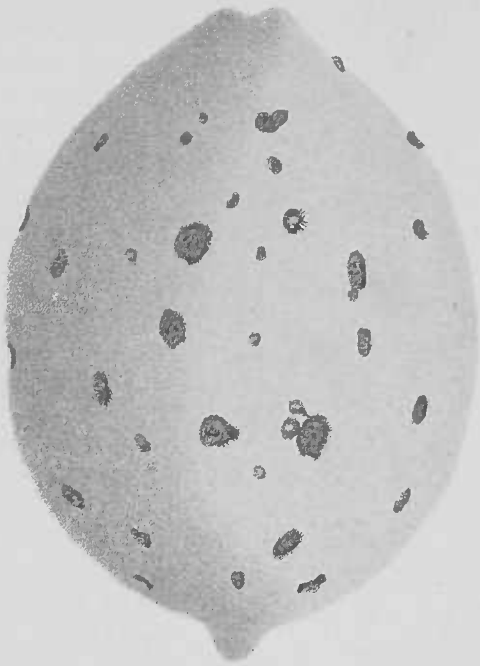
## PLATE II.

BLACK-SPOT OR ANTHRACNOSE (*PHOMA CITRICARPA*).

Figs. 1 and 2. "Black-spot" on orange and lemon.

The round sunken spots are of a dark brown colour, and nestling in the centre are the minute, black, punctiform pustules, visible to the naked eye (natural size).



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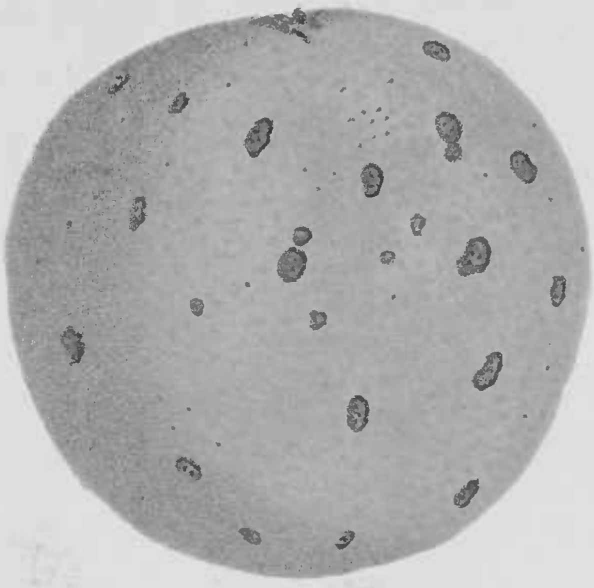

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## ANTHRACNOSE OR "BLACK SPOT."

(*Phoma citricarpa* n. sp.)

This is a disease which has not been met with in Victorian orchards, but it is quite common on the fruits sold in Melbourne and suburbs. It is very common on oranges, mandarins, and lemons imported from Sydney, where it is very prevalent, and also in surrounding districts. It spots the fruit, and when well developed renders it unsightly and almost unsaleable—lowering its market value as well as interfering with its keeping quality. I find that such fruits soon become rotten and fall a ready prey to "Blue Mould," &c., so that all such should be rigidly excluded from shipments to England.

*Symptoms.*—The spots are round and sunken and of a dark-brown colour, at first whitish or greyish towards the centre, but ultimately they may become one uniform tint. They are either isolated or run together and vary in size from one-eighth of an inch or less up to large irregular confluent brown patches of half-an-inch or more. In the centre of these spots there soon appear a number of minute black dot-like pustules, just visible to the naked eye, and which are the cases containing the reproductive bodies or spores. (Plate II.) These pustules have a minute opening at the top to allow the escape of the spores, which may be wafted by the wind or carried by animals, and thus the disease is rapidly and widely spread.

*Effects.*—In certain districts of New South Wales it causes considerable damage to the orange crop, and lemons seem to be very subject to the disease. It is found on still green fruit, but it spreads most rapidly when the fruit is ripe, the pustules developing best under these conditions and producing their innumerable spores. The disease readily spreads from fruit to fruit and from tree to tree, and when badly affected the fruit drops and is useless. It is sometimes spoken of slightingly, as if it were only a skin disease; but its effects are much more far-reaching, for not only does it spread to apparently clean fruit in the case, but it induces rottenness and decay. It is a matter of common observation that such fruit does not keep, and if clean and unclean fruit, plucked at the same time, is kept under similar conditions, the rapid decay of the spotted fruit is very marked.

*Cause.*—It is rather surprising that a disease which seems to be so prevalent in New South Wales orchards should have been so long neglected and its true cause not investigated. It is a comparatively easy matter to determine the fungus when the fructification is so common in the shape of the minute black pustules. The so-called "practical man" usually considers the scientific determination of disease-causing fungi as unnecessary, and not likely to help him in any way in combating disease. But when it is considered that it is necessary to diagnose the disease and determine the cause before remedial or preventive measures can be rationally applied, it will be seen that this is really the first step to be taken.

The fungus producing Anthracnose or "Black Spot" is a new species of *Phoma*, which I have named *Phoma citricarpa*. The spore-cases are of small size, and the spores are very minute.

In Florida a leaf-spot has been found on both sweet and wild orange trees, which has also been named Anthracnose, but it is due to quite a different fungus, known as *Colletotrichum adustum*, Ellis. There is also a black disease of the orange known in Italy as "La Nebbia," and with which this one has been confounded, but it is caused by an entirely different fungus (*Pleospora hesperidearum*, Catt), the spots being covered by a black powder. A careful examination of the fungus settles its identity at once.

*Treatment.*—This disease may appear by itself or along with other diseases, such as the so-called "Melanose," and the same treatment may be applied to both. Not having had an opportunity of carrying out experiments on the disease further than to show that the spores are prevented from germinating by dilute Bordeaux mixture, I can only suggest, and not recommend—

1. The skins of diseased fruits should be burnt in order to prevent the spores reaching fresh growing fruits.
2. The cases carrying the diseased fruit should be disinfected. This may be done by dipping the cases for a few minutes in boiling water.
3. Drainage should be particularly attended to, since citrus trees are very sensitive to water lodging at the root.
4. Spray with Bordeaux mixture as soon as the fruit sets, as recommended for the "False Melanose." This may be continued every four weeks up to about a month before the ripening of the fruit.
5. Also spray with Bordeaux mixture after the crop is gathered, to destroy the inevitable spores lodging about the tree.
6. Sulphate of Iron, at the rate of about half-a-pound, may be applied to the feeding roots of each tree, either by sprinkling and watering, or by dissolving in water, at the rate of 1 oz. to 3 gallons. Every reasonable precaution should be taken to prevent the introduction of the disease into Victoria.

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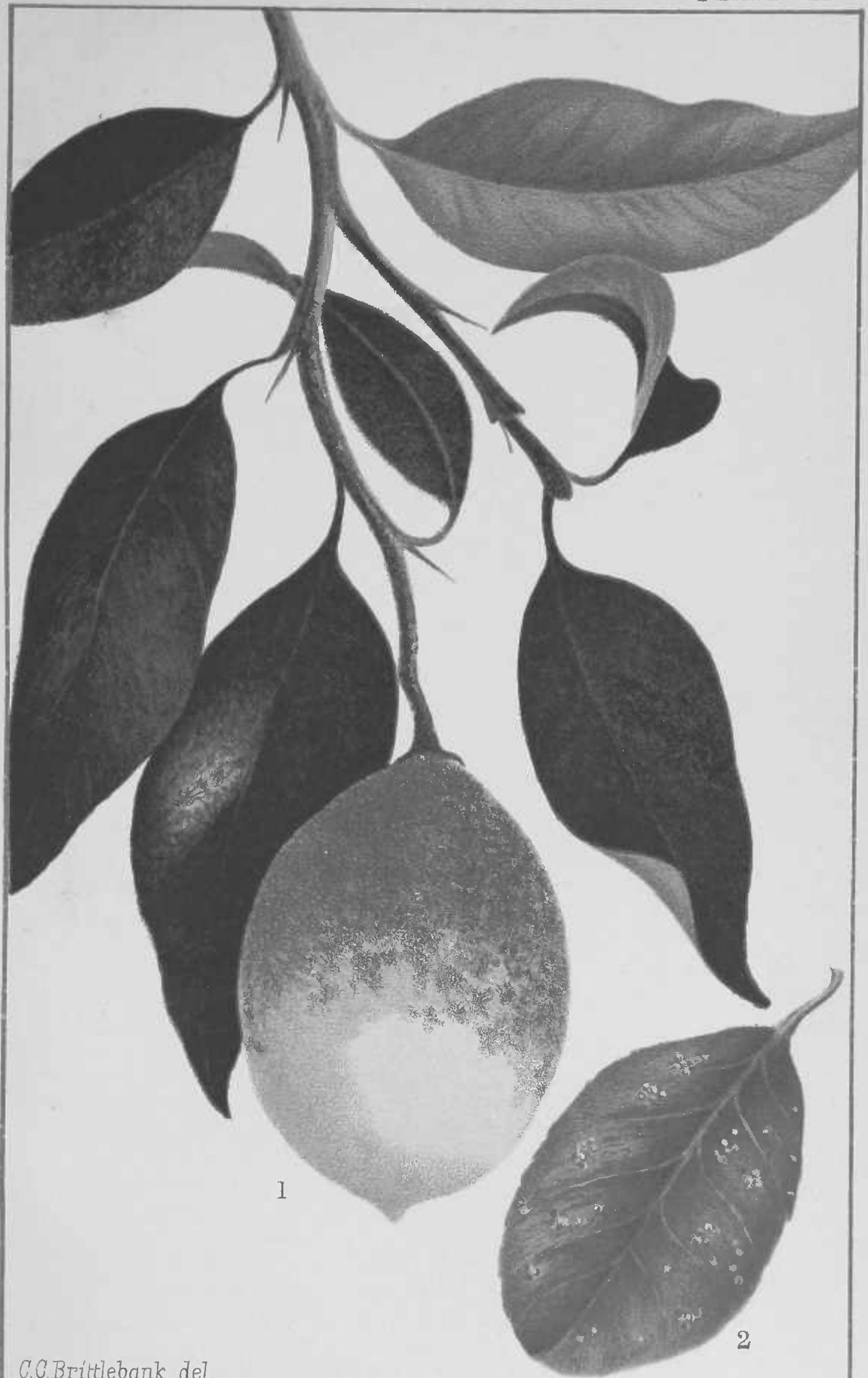
## PLATE III.

SOOTY MOULD OF ORANGE AND LEMON (CAPNODIUM CITRICOLUM).

Fig.

1. Twigs, leaves, and fruit of lemon coated with Sooty Mould (nat. size).

2. Orange leaf, showing the minute brick-red tubercles of *Microcera coccophila* parasitic upon and destroying the Scale Insects. The "honey-dew" secreted by these insects serves to nourish the "Sooty Mould" fungus (nat. size).

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## SOOTY MOULD OF ORANGE AND LEMON.

(*Capnodium citricolum*, McAlp.).

The disease of Sooty Mould has been known since the beginning of the century, chiefly in southern Europe, and now wherever citrus trees are grown. It passes under various common names in different countries, such as "Morfea," "Fumago," "Nero," and "Mal di cenere" in Italy, the latter name referring to the ashy-grey incrustation, which afterwards becomes black; "Russthau" or Soot-dew in Germany; "Sooty Mould" in Florida; and "Fumagine," "Black Mildew," "Black Blight" among ourselves. It is likewise often called "Smut," from its appearance, but does not belong to that division of fungi which includes the true Smuts. And the scientific names applied to it have been equally varied, for the fungus assumes a variety of different forms, to which different names have been given. In fact, this "Sooty Mould" affords a very good illustration of what has been called Polymorphism, the same fungus appearing under different guises at different stages of its development. It is one of those diseases which seemingly does not do much damage, but which in the aggregate is very injurious. It is dependent on certain insects for its spread, and as these multiply it also increases. Trees are sometimes met with largely covered with the sooty fungus, and, as it spreads rapidly, every precaution should be taken to arrest its progress.

*Symptoms.*—It occurs on the living leaves, particularly on the upper surface, but it may also appear more or less on the under surface. It is also found on the branches, as well as on the fruit, usually on the upper or stem end as the fruit hangs down (Plate III., Fig. 1). It forms black soot-like incrustations, peeling off in flakes, like a continuous membrane of black tissue-paper. It is entirely superficial, not penetrating the tissues in any way. There are all sorts of gradations in the nature and extent of the fungus. It may appear at first just like a sprinkling of dust on the leaf (in fact, growers do confound it with dust), then of a dark muddy grey, peeling off as a thin papery layer, and finally as a sooty crust, soiling the fingers when rubbed. At times there is a considerable admixture of dust with the filaments, and then it is usually checked in its development. The depth of the colour is evidently largely influenced by the relative amounts of more or less colourless and coloured hyphæ, both of which are usually present.

*Effects.*—This fungus does not produce any marked injury to the tree at first; as, when the "Sooty Mould" is removed from a leaf, the surface beneath is often as green and glossy as a healthy one. The injury is rather of a mechanical nature, and, combined with the scale insects sucking the juices, there is often considerable damage done. The fungus will interfere with the process of assimilation by preventing the access of light and the escape of watery vapour and other gases. Indirectly this will hinder the growth of the tree and affect the production of bloom and of fruit. The leaves are less able to withstand the effects of drought or other unfavorable conditions, and if the young fruit is attacked, its development is hindered and generally it remains insipid. The injury done to the tree is not so readily realized by the grower as the damage done to the fruits. They are thereby rendered unsightly and unsaleable, and have to be thoroughly cleaned before marketing. This entails expense, and, as experiments have shown, interferes with the keeping quality of the fruit, apart from much of it being small in size and not properly ripened. Dr. Berlese has called attention to the serious effects of the disease on oranges and lemons in Italy. Not only are the fruits much smaller, and sometimes not produced at all, but the yield in affected groves may be reduced to one-tenth of their normal in a year. Keeping a tree in a healthy condition thus means a deal to the grower. The leaves do their work properly and encourage healthy root-action, the young wood is well developed, and the blossom is abundant; the fruit produced is allowed to ripen and attain its normal size and colour, and its keeping quality is maintained, while the vitality of the tree itself is more abundant and more lasting.

*Causes*—The Sooty Mould or black fungus is not a parasite, as has already been pointed out, and does not live at the expense of the plant, but by means of the so-called honey-dew or sugary secretion of scale insects. The fungus itself belongs to the division in which the spores are produced in little bags or *asci*. This is the highest form of fructification, but there are at least seven different stages or reproductive phases in the life-history of this fungus. It is provided with means of multiplication and spread for all conceivable circumstances. If nourishment is scanty, then the joints of the filaments can break up and serve as reproductive bodies. Then the ends of the filaments can detach portions as *conidia*, to be carried by the agency of the wind, insects, birds, or animals to other trees. Several kinds of flask-shaped bodies produce their innumerable spores, and finally the asci, with their ascospores, can withstand cold, heat, or drought, and renew the fungus when favorable conditions return. These different stages have been somewhat fully described and figured in a paper by me, printed in the *Proceedings of the Linnean Society of N.S.W.*, 30th September, 1896, so that the subject need not be further enlarged upon here. Given a supply of food, and it is easily understood how the wind-borne spores can pass from tree to tree and from grove to grove, until an entire district is infected.

*Connexion with Scale or other Insects.*—On the orange leaves, for instance, affected with scale insects, you may sometimes find little clear gummy globules, sweet to the taste. These are produced by the insects as figured and described by the late Mr. Maskell, in his work on New Zealand Scale Insects. "In many cases," he writes, "they exude, in the form of minute globules, a whitish thick gummy secretion, answering probably to the 'honey-dew' of the Aphididæ. This secretion drops from them on to the plant, and from it grows a black fungus, which soon gives an unsightly appearance to the plant. This fungus or 'smut' is an almost invariable indication that a plant is attacked by insects, and may, indeed, give a useful warning to tree-growers." And as J. G. O. Tepper, of Adelaide, has shown, there is a complex relation between the different forms of life used by the plant for protective purposes, and if one of the checks is withdrawn or diminished the balance is disturbed and disorder ensues.

1. The *Scale* or other insects are used indirectly to attract the ants by their sweet secretion.
2. The *Ants*, like a standing army, protect the foliage against the attacks of leaf-eating animals.
3. The abundance of honey-eating *Birds* is necessary to keep the scale or other insects within reasonable bounds, as they not only use the honey, but eat the insects as well.
4. The reduction of these birds by man tends to favour the increase of the scale insects and their produce.
5. The scale and other insects now get the upper hand, and the ants protecting the insects also favour their increase.
6. The consequence is superabundance of honey-dew, and this is taken advantage of by the germs of the fungus to spread and multiply.

Thus the destruction of the honey-eating birds has brought about an increase of the honey-dew, and consequently of the "Sooty Mould."

The dependence of the Sooty Mould on the presence of the scale or other insects secreting "honey-dew" indicates at once the line of treatment—that if the scale be destroyed the food supply of the Sooty Mould is cut off. The Scale-Ant-Bird-Fungus problem opens up large issues as to man's interference with nature which cannot be followed out here; but it shows on the face of it that, even for the eradication of some fungus pests, insectivorous birds should be protected for the benefit of the grower.

*Entomogenous Fungi as aids against the "Sooty Mould."*—It is interesting and profitable to observe the appearance of other checks to the spread of the scale insects. While examining leaves infested with "Sooty Mould" from New South Wales, I discovered a fungus parasitic on the Red Scale of Orange and

Shaddock (*Aspidiotus aurantii*). It was found to be a European species, the Coccus-loving Microcera (*Microcera coccophila*, Desm.—*Sphaerostilbe coccophila*, Tul.), and had previously been found in Queensland by Mr. F M. Bailey, infesting a Coccus on the lemon (Plate III., Fig. 2.) Another has been found on the "White Louse" or "White Orange Scale" (*Chionaspis citri*, Comstock), and it is the Straight-spored Microcera new to science (*Microcera rectispora*, Cooke and Mass.).

The discovery of these fungi parasitic on scale insects opens up a wide field of inquiry, and suggests the possibility of employing them as a means of ridding orchards of such insects. Already fungi have been utilized in fighting insect pests, and a well-known case is that of the Chinch Bug in America which was kept in check, if not almost stamped out, by this means. In Florida several fungi were found on the honey-dew secreting insects, and, although no results have as yet been obtained from experiments, yet the efficiency of the fungus is undoubted. "Extensive field observations indicate that Aschersonia [the parasitic fungus] will prove a valuable aid in keeping the mealy wing in check, and thus controlling the Sooty Mould. In the town of Gainesville, where the Sooty Mould has been very abundant and destructive for a number of years, it is generally acknowledged that the trees are gradually recovering, and this is probably to be attributed to the presence of Aschersonia, which is very abundant. On many trees it was difficult to find a living larva or pupa of the mealy wing, and in such cases the leaves were thickly dotted over with the pustules of Aschersonia."

Generally speaking, fungi are readily spread by means of the spores which they usually produce in such abundance. The ants which feed upon the honey-dew secreted by the insects may carry them from place to place, as well as flies of various kinds which come in contact with the affected leaves. But artificial means may be resorted to. The spores may be mixed up with water and applied as a spray, or branches with the fungus may be cut off and hung over trees infested with the insect, in order that the rain may wash down the spores ; or the most satisfactory of all is to transplant young orange trees infested with the fungus into groves where the insect occurs without the parasite. Entomologists as a rule are not sufficiently acquainted with fungi to appreciate their importance, and, therefore, this method of keeping insects in check has not as yet been extensively tried.

*Treatment.*—It will be evident from the preceding that the only sensible and efficacious treatment will be to get rid of the insect which provides nourishment for the fungus. Mr. French, the Government Entomologist, informs me that the principal scale insects attacking the citrus leaves infested by "Sooty Mould" are the Red Scale (*Aspidiotus aurantii*, Mask.) and the

Black or Brown Olive Scale (*Lecanium oleae*, Bernard), and for these the treatment he recommends is the kerosene emulsion or resin wash. Mr. Froggatt remarks of the latter scale—"Perhaps more oranges are rendered unfit for market by the action of this coccid than any other pest, except Red Scale, for, though the scales do not get on to the fruit themselves, they frequently cluster round the stalk, and, discharging the honey-dew, cause the upper half of the orange to become smothered with black smut (*fumagine*), which takes some time to remove." Destroy the insects that deposit the sugary secretion, and the accompanying fungus will be starved out. Recent experiments have been carried out in Florida as to the best treatment, and the results are given in Bulletin 13 of the United States Department of Agriculture, on "Sooty Mould of the Orange and its treatment," by Webber (1897).

The following measures may be recommended :—

1. Prune off branches badly attacked with sooty mould, and burn.
2. Systematically collect and burn all water shoots at the beginning of each spraying season.
3. Spray with Resin Wash. This has been found to give uniformly good results in Florida. The best time to spray is when the larvæ of the scale are on the move. As this spray is easily washed off by rain, it should not be applied during rain, nor when rain is likely to fall within two or three days. The dense foliage of Citrus trees render them rather difficult to spray, but it is a good practice to trim out the tree from within. As it is absolutely necessary to wet the under surface of the leaves, the operator must get under the tree and spray outward, as well as from the outside. Plenty of the material should be used, on an average from 15 to 20 gallons per tree.
4. Fumigation with hydrocyanic acid gas, by means of tents covering the trees, has been found effectual. This gas is an animal poison, and does not seem to be effective against fungi ; but in this particular instance it rids us of the fungus by destroying the source of its food supply, viz., the scale insects. Forty-minute treatments have given good results. (See Appendix 2.)
5. Fungi parasitic upon the scale insects, such as the Coccus-loving Microcera (*Microcera coccophila*), should be artificially spread, in order to check the development of the insects.

I have not thought it necessary to recommend measures adapted for the removal of sooty mould alone. Alkaline washes, and even liquid starch properly applied, can do this ; but to clean the leaf temporarily, without reaching the seat of the disease, is simply to provide a fresh surface for the scale insects to act upon.

The formula for Resin Wash, as given in Webber's pamphlet, already referred to, is as follows :—

| | | |
|---|---|---|
| Resin | ... ... | 20 lbs. |
| Caustic soda (98 °/₀) | ... | 4 ,, |
| Fish oil (crude) | ... | 3 pints |
| Water | ... ... | 15 gallons. |

Boil about 13 gallons, and add the three constituents, boiling until the resin is dissolved, which will be in a few minutes. Add 2 gallons more of hot water, and this becomes a stock solution.

When required for use thoroughly stir it, in order to uniformly mix the precipitate at the bottom, and take 1 part of the stock solution to 9 parts of water. If required for immediate use, the hot solution could be poured directly into the spray tank, and diluted with 9 times as much water, or 135 gallons, in order to bring it up to 150 gallons.

In the October number (1898) of the *Agricultural Gazette* of New South Wales a slightly modified formula is given :—

| | | |
|---|---|---|
| Resin | ... ... | 16 lbs. |
| Caustic soda... | ... | 6 ,, |
| Fish oil | ... ... | 3 pints. |

Boil 10 gallons of water, and add the above ; keeping it boiling and stirred till the resin is dissolved. Add hot water, a little occasionally, until the whole is made up to 20 gallons. Dilute in the proportion of 4 gallons of hot water to 1 gallon of the hot solution, thus making it 100. It is recommended to keep the solution as hot as the hose will stand.

*Removal of "Sooty Mould" from the fruit.*—In America there are several methods of removing the fungus from the fruit, when it seriously affects its market value, but these are only makeshifts. It never has the same appearance and quality as naturally clean fruit, and the process is tedious and costly. There are what may be called the dry and wet methods. In the dry method a revolving barrel is used, the inside of which is carefully cushioned to prevent the oranges being bruised. Dry sifted sawdust, principally fine, is placed in this, and the fruit is rolled for several minutes, then the handling afterwards removes any trace of sawdust. Of course the sawdust has to be frequently changed, as it soon becomes foul. The wet method consists in having a similar revolving barrel without the cushions, and the axis must not pass through, as it would bruise the fruit. Sawdust and water mixed is the cleansing agent, and after removal in a few minutes the fruit is rinsed and spread out in trays to dry. Another method, and the most thorough one, is to scrub each fruit with a wet rag and soap added to the water.

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# PLATE IV.

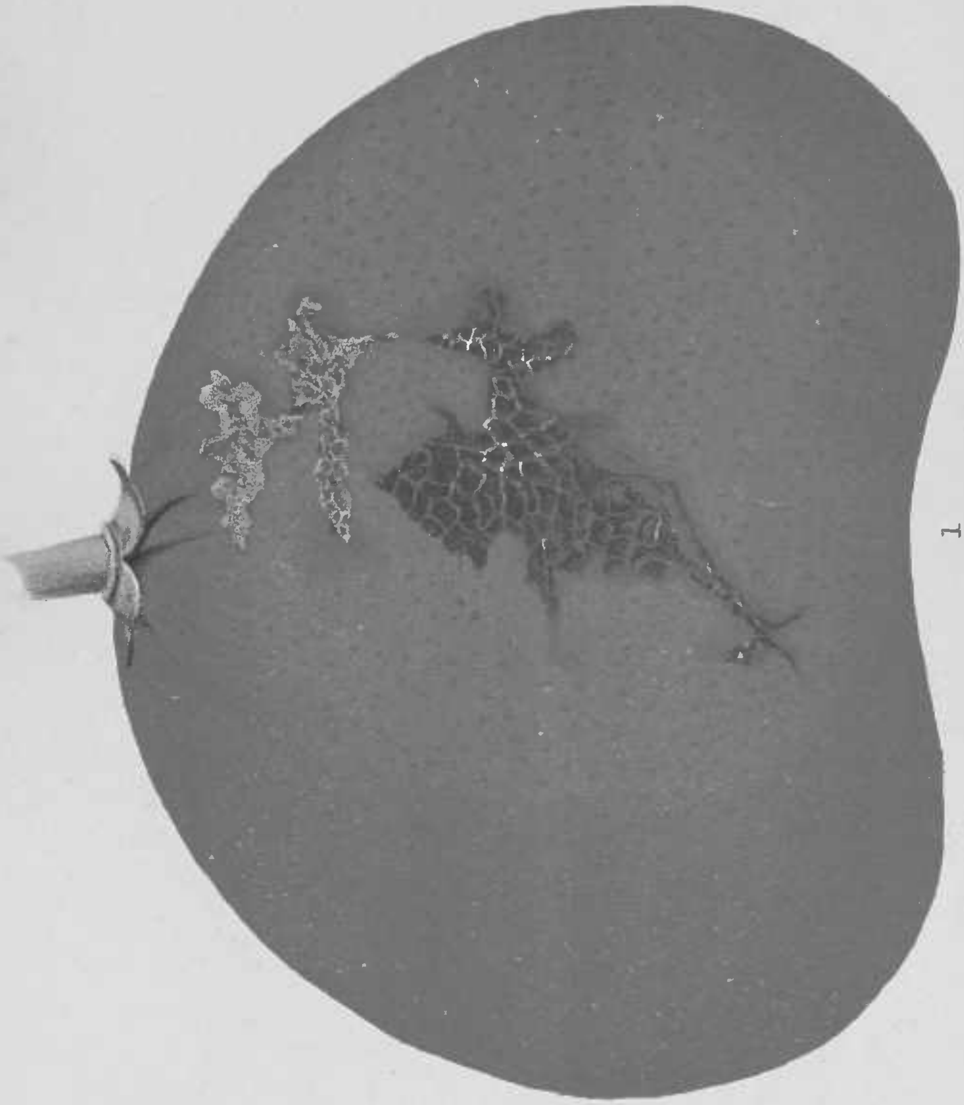
BLACK SCURF OF CITRUS FRUITS (CONIOTHECIUM).

Fig.

1. Shaddock showing the skin in some places coated with a black mould, and in others with dirty-grey scurfy patches, where the fungus has become detached in fine flakes. This disease resembles one stage of Sooty Mould, only it does not peel off and leave the surface unbroken (nat. size).

2. Clusters of Conidia which reproduce the fungus ($\times$ 540).

PLATE IV.



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## "BLACK SCURF" OF CITRUS FRUITS.

(*Coniothecium scabrum*, n. sp.)

There is a scurfiness often observed on Citrus fruits, which may cover a smaller or larger area of the skin, caused by this black, soot-like fungus. It might readily be mistaken at first for the "Sooty Mould," and even microscopically it resembles a stage of it, but it is distinguished by not being necessarily accompanied or preceded by scale insects, and chiefly by the skin disease it produces. The Sooty Mould may peel off in flakes or be easily rubbed off, leaving the skin quite unbroken and uninjured, except possibly rendering it a little paler in colour ; whereas in this case the surface of the skin is cracked and ultimately becomes scurfy.

*Symptoms.*—The appearance on the fruit is very characteristic. It first begins as little black depressions, causing the skin around for a considerable area to become of a yellowish-green. Then it gradually spreads to form large sooty-black patches, the epidermis cracking all over into minute irregular areas. Finally the black masses of conidia are detached in fine flakes, and there is a dirty-grey, scurfy, depressed patch left to indicate where the fungus had been.

*Effects.*—As in the case of so many other skin-diseases, it is not the damage actually done to the fruit, nor the unsightly appearance produced by it, which is most important, but the after effects, causing the fruit to be more liable to decay, and thus interfering with its keeping qualities, as well as to be more readily attacked by other parasites.

*Cause.*—The black soot-like substance is mainly composed of reproductive bodies, which are composed of mulberry-like clusters of brown cells. The cracking of the skin is caused by the filaments of the fungus bursting through to produce their conidia at the surface, and small patches of the skin are readily detached bearing these bodies with them. This causes the roughness of the skin and the various symptoms already described.

*Treatment.*—No actual experiments have been carried out as to treatment, but general healthy growth should be encouraged. As this is a form of scab, the recommendations given for dealing with it should be followed.

# PLATE V

SCAB ON ORANGE AND LEMON (VARIOUS FUNGI).

Fig.

1. Greyish-brown scab on green Lemon, caused by *Cladosporium subfusoideum* and *Diplodia citricola* (nat. size).

2. Dirty-white scab of yellow Lemon, caused by same fungi (nat. size).

3. Grey scab of Orange, caused by *Sporodesmium griseum* (nat. size).

PLATE V.


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## "SCABBING" OF FRUIT AND LEAVES.

The term "Scab" is so loosely applied and is susceptible of such a variety of meanings that it is advisable to give some general definition before discussing the agencies by which it may be caused. If the normal smoothness of the surface tissue of a fruit or leaf is studded with elevations or depressions which are partly or entirely rough and broken, with a dead or discoloured appearance, then it will be here spoken of as "Scabbed." The active factors in the production of these symptoms are so various and so commonly associated with other possible agencies, that it is often no easy task to determine the primary cause. Some mechanical agent, such as a thorn, or more frequently the puncture of some mite or insect, may so irritate the skin of the fruit as to induce a flow of the essential oil, which spreading over the skin becomes oxidized and converted into a resinous material which interferes with physiological processes and produces scab-like elevations. To the disturbing effect upon the cells of the surface tissue, due to the growth of certain fungi, may also be traced the production of unsightly warts or depressions, accompanied or not by the exudation and oxidation of the essential oil. On leaves the presence of certain animal or vegetable parasites may stimulate the formation of corky tissue, thus giving them a scabby appearance. Hence any reference to "scab," as if it were a specific disease, due to a definite organism, is not in accordance with the facts, and is to be deprecated. Only those forms of scab which are produced by or associated with fungi will be dealt with here, with the solitary exception of the corky formation on the under surface of the leaf. One great reason why it is often so difficult to determine the exact species of fungus causing the scab is that generally the vegetative phase only of the fungus can be found, though it may be that the detached flakes afterwards produce the fructification.

It appears that scab has been noticed mostly on the Lemon, and that Australia has a comparatively early record of it, owing to the favorable nature of the climate. At present it has rather a limited geographical distribution, being absent from Europe and Africa, as far as known, but occurring in Japan, America, and Australia. It first appeared in Florida about 1884, and, according to Swingle and Webber, it was undoubtedly introduced from Japan. There is a scab disease recorded on the Lemon-leaf in Queensland as early as 1876, and it would be interesting to trace its origin, but probably it might be found on some of the native Citrus trees.

In October, 1892, there is a note in the *Agricultural Gazette* of New South Wales recording its occurrence in that colony :—" Orange scab has lately appeared on the orange trees growing in the districts around Dural, Galston, and Kurrajong. It appears on the fruit of the orange tree, and is often very severe."

In several colonies, including Victoria and South Australia, it is just beginning to attract attention, so that the time is ripe for spreading useful information about it.

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## "SCABBING" OF FRUIT.

On the fruit it is very varied in its character, owing to the different fungi causing it, and the varying conditions under which it occurs.

In "Lemon-scurf" (*Cladosporium furfuraceum*) dingy white patches are formed, ultimately becoming dotted over with brownish-black spots, and these discoloured portions readily peel off in minute flakes, leaving the Lemon scurfy in appearance.

In "Grey-scab" of the Orange (*Sporodesmium griseum*) the patches are flat or slightly depressed, almost round, and breaking up into minute flakes, slightly darker (Plate V., Fig. 3).

"Greyish-brown scab" of the Lemon (*Cladosporium subfusoideum*) occurs on both ripe and green Lemons and Citrons. On the green Lemon from Parramatta, New South Wales (Plate V., Fig. 1), there was a greyish-brown scab, mostly on one side, with clusters of black pustules, just visible to the naked eye, on the darker portions. These were the perithecia or spore-cases of *Diplodia citricola*, which fungus was associated with *Cladosporium*. The yellow Lemon from Wandin Yallock, Victoria (Plate V., Fig. 2), had irregular pallid to dirty-white or even darkish-brown patches on the skin, sometimes of considerable size, not only spoiling the appearance of the fruit, but interfering with its proper ripening, as well as its keeping qualities. The affected specimens, although yellow, were below the normal size, and sometimes a continuous scab-like surface occupied the whole of one side. *Cladosporium* and *Diplodia* were present, as in the green specimen.

The "False Melanose" is simply a form of scab, but as it is treated separately and specially (Plate I.), I need not refer to it here.

The "Black-scurf" of Citrus fruits has also already been described (Plate IV.).

In "Ruddy-brown scab" of the Lemon (*Ovularia citri*), the fruit is sometimes rough all over with hard excrescences, and the warts are covered with a whitish coat of mould belonging to the fungus.

There is a "Brownish-black scab" on Oranges, Lemons, and Citrons, caused by a very commonly distributed fungus (*Phoma omnivora*), which also attacks branches and leaves, producing a withering and decay at the tip. The "scabs" are at first of a dirty-grey colour, becoming brown or even dingy black, usually appearing on one side of the fruit, and little patches are gradually being detached in thin flakes (Plate VIII.).

Verrucosis or scab so prevalent in Florida, in which both the leaf and fruit of Oranges and Lemons are attacked, has not been detected in Australia. It forms excrescences up to two-fifths of an inch, the fruit is covered with lumps of an irregular pyramidal shape, and the wart is coated with a delicate fungus (*Cladosporium sp.*), at first grey, then dusky, at last black.

# PLATE VI.

LEAF-SCAB OF LEMON (VARIOUS FUNGI).

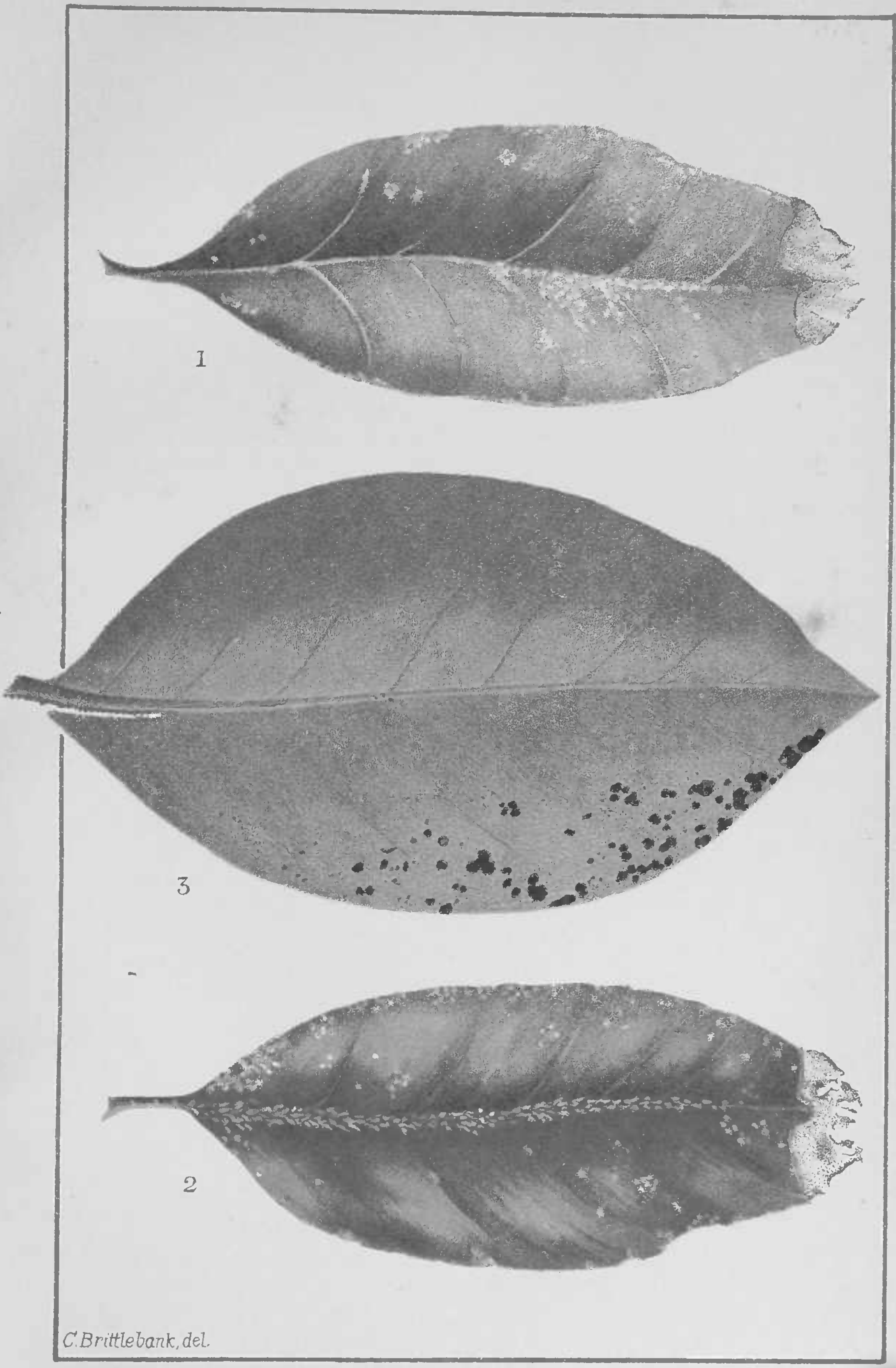
Fig.

1. Upper surface of Lemon leaf (nat. size).

2. Under surface of same leaf.

   The leaf on both surfaces was largely covered with "scab," and towards the tip where there was no scab withering and decay had set in. No less than six fungi were found upon this single leaf, together with the remains of a remarkable Scarlet Mite, which probably was the primary cause of disease.

3. Under surface of Orange leaf, showing numerous brown pustular bodies, due to the excessive development of corky tissue.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## "SCABBING" OF LEAVES.

I am indebted for the specimens on which this account is based to Mr. H. Tryon, Government Entomologist of Queensland, who was the first to call attention to the subject in Australia, and published a full description of a fungus associated with Leaf scab ten years ago in his *Report on Insect and Fungus Pests.* In Queensland the leaves of both Oranges and Lemons, including the petioles, have been found effected with "scab," and the first fungus found associated with it was *Ramularia scabiosa* n. sp. In this instance the scabs were very conspicuous on older leaves, becoming elevated and rough, and as many as 50 have been counted on a single leaf. They may be equally distributed on both surfaces, sometimes only occurring on one, and two or more may run together. The usual effect upon the tree is to cause it to shed its leaves after becoming yellow, and consequently to produce poor crops or none at all. In a vigorous tree, however, the leaves may persist and not become discoloured. Seedling trees were found most liable to the disease, and the Lemon is specially subject. The Lemon leaf figured in Plate VI., Figs. 1 and 2, was gathered at Corroy, in Queensland, on the 3rd April, 1898, and is rather remarkable for the crop of fungi found upon it. There were numerous ruddy-brown scabs, mostly aggregated along the midrib or near to it, and also along the margin, occasionally solitary, but generally run together, and forming irregular, elevated masses on both surfaces of the leaf. A few scabs also occurred on the petiole. The terminal portion of the leaf was pale and withered, and the whole had an unhealthy appearance.

Six fungi were found on the leaf altogether, four associated with the scabs and two on the withered tip portion. They were as follows :—

1. Phyllosticta scabiosa.
2. Sphaeropsis citricola.
3. Pestalozzia funerea.
4. Sporodesmium triseptatum.
5. Colletotrichum glœsporioides.
6. Sphaerella citricola.

The main object of the inquiry was to discover the cause of the extensive scabbing. Mr. Tryon found a remarkable scarlet Mite present, and this he believes to be the primary cause of the scab-like bodies. Then the question arises, are the fungi found in connexion with the scabs of the nature of saprophytes, settling down upon the galls produced by this particular Mite? From the nature of the fungi concerned there is no definite evidence to connect them with the production of the scabs; and, taking all the circumstances into consideration, I am inclined to agree with Mr. Tryon that the scabs are primarily caused by the Mites, and then the fungi follow in their wake.

The Orange leaf figured in the same Plate (Fig. 3) is from South Australia, but the appearance presented by it is common enough with us. The under surface has numerous brown irregularly-shaped pustular bodies upon it, sometimes becoming almost black in colour. When a section of the leaf is made this scab-like or warty formation is found to be due to an excessive development of corky tissue at these particular spots. It is not easy to explain why corky tissue should be developed in this irregular and erratic fashion on the under surface of the leaf; but since cork prevents excess of evaporation and is most developed on leaves (of the eucalypts, for instance) in desert country, the opinion may be hazarded that it is an effort of the tree to retain as much moisture as possible in periods of drought or in dry situations.

*Conditions favouring disease.*—Where the air is moist and the land low the scab-producing fungus flourishes most abundantly. And it is found that in high and dry situations, especially where the atmosphere is comparatively dry during the growing season, there the disease is almost unknown.

Since the germinating conidia can only penetrate young and growing tissue, it is when the leaves and fruits are growing rapidly that the most danger is to be apprehended. If the fungus can be kept in check at this season, then little damage is usually done later on.

*Cause.*—As already indicated, the causes of scabbing may be numerous and varied, and each case must be determined on its merits. In the Potato scab, for instance, the explanations to account for it are nearly as numerous as the investigators who have studied the disease, and many consider that a wound of some sort precedes the appearance of fungi. In the Apple and Pear scab, there is a definite fungus known to produce it; but in other cases fungi may be associated with "scabbing" without being the primary cause of the disease. Infection experiments would be required to settle the point.

Where fungi are concerned they mostly belong to the group of Moulds, or what is technically known as the *Hyphomycetes*, but in some instances given, the fungi belong to the group in which there are perithecia or spore cases. It is interesting to note that in every such case there was a mould associated with it which was probably the conidial stage of the higher fungus. The mycelium or threads of the fungus may only be found penetrating the tissues, or they may appear on the surface as a delicate network. There is generally a scarcity of fructification, so that it is not always easy to tell the exact species of fungus concerned, but it is probably spread and multiplied by means of the fine flakes constantly being thrown off and readily scattered by the slightest breath of wind.

*Treatment.*—Where the disease is of fungus origin, all those measures should be used which are inimical to the growth and spread of the fungus—

1. Plant on dry soil, and, if possible, choose a locality where there is little rainfall during and immediately after the blooming season.
2. Remove and burn or bury deep all diseased fruits, whether on the tree or on the ground.
3. Spray with Bordeaux mixture, as in "False Melanose."

### References.

Cobb (N. A.)—"Letters on the Diseases of Plants." Ag. Gaz., N.S.W., vol. VIII., pt. 4, p. 229 (1897).
[Verrucosis is just referred to, but it is not stated whether it exists in New South Wales or not.]

Cobb (N. A.)—"Grey Scab of the Lemon." Ag. Gaz., N.S.W., vol. VI., pt. 12, p. 865 (1895).

Tryon (H.)—"Report on Insect and Fungus Pests." Dept. Ag., Queensland, p. 144 (1889).

"Experiments with Orange Scab." Ag. Gaz., N.S.W., vol. III., pt. 10, p. 833 (1892). [Experiments suggested.]

# PLATE VII.

"WITHER-TIP" OF ORANGE, LEMON, AND CITRON (*Phoma omnivora*).

Fig.

1. Twigs of Lemon showing the dead portions of branches, as well as the effects of the fungus on still green portions (nat. size).

2. Green portion magnified showing dirty-grey patches studded with the minute dark pustules of the fungus.


1
2
C. Brittlebank, del.

## " WITHER-TIP " OF ORANGE AND LEMON.

(*Phoma omnivora* n. sp.)

There is a disease of both Orange and Lemon trees, which have been sent to me from West Australia and South Australia, as well as from different districts of Victoria, and I happen to have it on an Orange tree in my own garden. It is called by most growers " Die-back," because the twigs die from the tip downwards, but it has nothing to do with the disease known under that name in Florida. The term is a very convenient one, so long as no definite cause is known, and had the name not been appropriated I would probably have used it as fairly descriptive of the present disease. However, I have named it " Wither-tip," since the leaves as well as the shoots often wither and die from the tip downwards. This disease, locally called " Die-back," is also known in New South Wales, and in the Annual Report of the Department of Agriculture, Queensland, for 1897–8, just received, it is reported on Citrus trees of the Darling Downs, &c. So the disease occurs in all the colonies, and may have been in existence for some time without being specially recorded.

Mr. Quinn, of South Australia, in forwarding me the specimen, wrote under date of 2nd September, 1898 :—"I am taking the liberty of forwarding in same packet a twig cut from a Lisbon Lemon, which my correspondent says is illustrative of the manner in which branches here and there upon the trees throughout a plantation are dying out." He also says Oranges alongside are quite healthy.

Then Mr. Heape, of Dandenong, under date of 8th December, 1898, wrote :—"Accompanying this you will find a collection of Lemon sprigs with 'Die-back' on them. The lot marked A, I found upon an Orange tree, and, strange to say, it is the only tree out of the thirteen Orange trees we have that shows it, and from off the only tree that was pruned. Of course it may not be 'Die-back.' " Both the Orange and Lemon twigs as well as the leaves accompanying them were badly affected with the " Wither-tip " fungus.

The solitary Orange tree in my garden, and indeed the only Citrus tree there, had shown signs of weakened vitality for the last two or three years, principally owing to the drought, and this season it became very marked, only a few flowers being formed, and the fruit when it reached about the size of a pea becoming black or brown. A number of the shoots were dead from the tips, principally the lower, but also the upper, and the affected shoots towards their base often sent out water-sprouts. It would appear that Lemon trees are specially subject, but the disease is also spreading to Oranges.

The disease known as "Die-back" or "Exanthema" is not known to occur outside of Florida, but to prevent mistakes being made a few of the more characteristic symptoms may be given—

1. The ends of the very rapidly growing shoots turn yellowish before maturing, and finally become stained reddish-brown in patches or throughout. This appearance is caused by a deposit in the outer cells of a reddish-brown resin-like substance. This yellowing and staining of the twigs, which is very general on the new growth all over the tree, is followed by the dying back of the affected twigs for a short distance, usually 3 to 6 inches.

2. Eruptions caused by the bursting of the bark very commonly occur on new and old twigs.

3. The foliage of diseased trees is always a very dark green; indeed this colour, so much desired by some growers, indicates that the grove is on the verge of showing the disease.

# PLATE VIII.

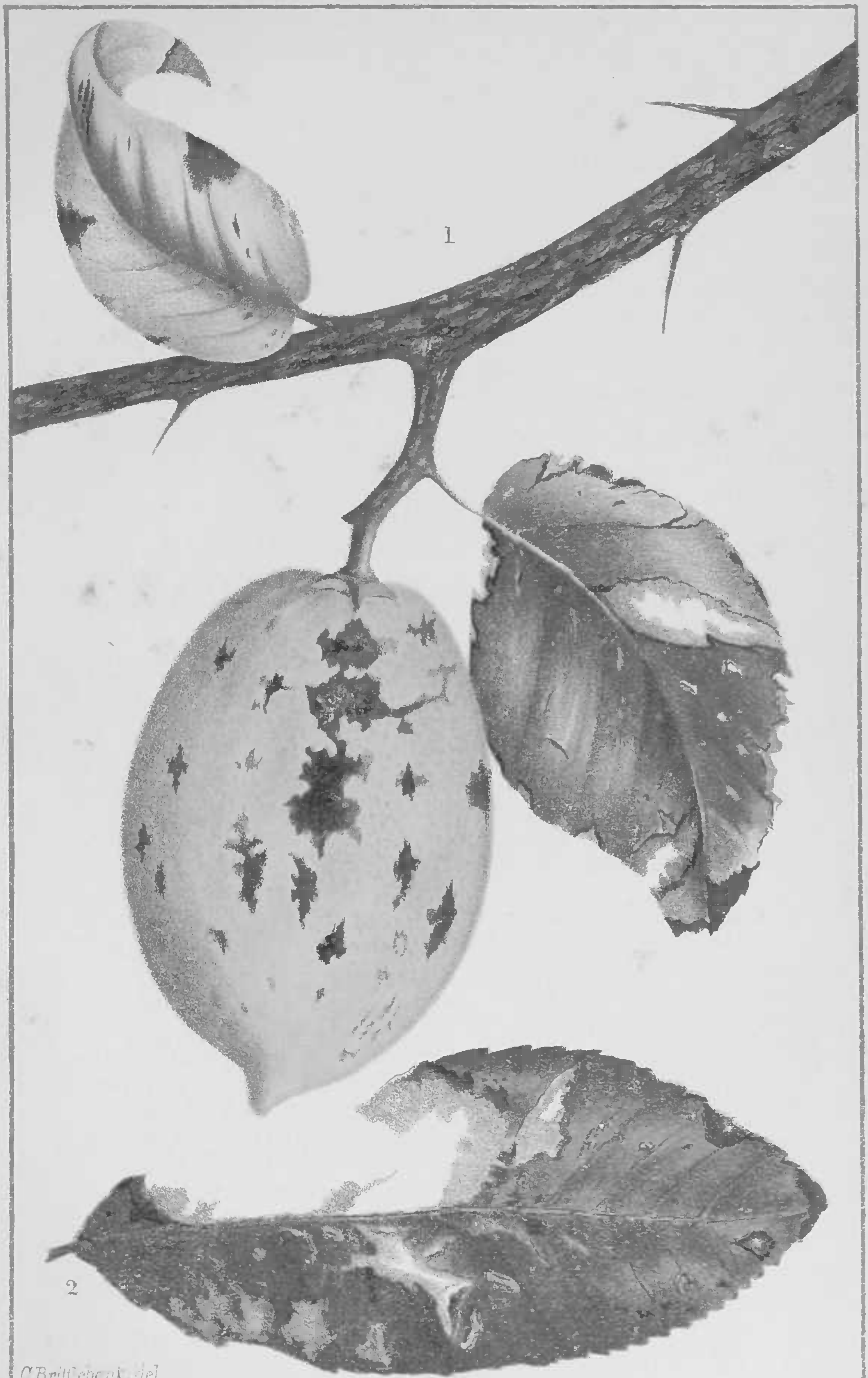
"WITHER-TIP" OF CITRON (*Phoma omnivora*).

Fig.

1. Branches, leaves and fruit of Knight's Citron, showing how the fungus destroys the bark, ruptures the leaf, and gives rise to a brownish-black scab on the fruit (nat. size).

2. Leaf from same tree, showing how the fungus disorganizes and destroys the tissues (nat. size).

The effects of this fungus were very pronounced, since the vitality of the tree had been weakened by an attack of "Collar rot," while a hailstorm also caused some damage.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C. Brittlebank, del.

*Symptoms.*—Wither-tip or brownish-black scab.

(*a*) *Leaf symptoms.*—On the under surface of the leaf, brownish to fawn-coloured or whitish-grey blister-like patches arise, usually running along the veins. Several of these gradually coalesce, and form large irregular blotches, and ultimately the tissue of the leaf is destroyed, leaving only the thin, membranaceous upper epidermis. This, too, soon becomes ruptured and torn, and round or irregular-shaped holes occur in leaf. When appearing near the tip, it causes it to wither, and the leaf is often gradually destroyed from the tip downwards. When the tissue is disorganized, various saprophytic fungi may appear to hasten and complete the decay. (Plate VIII., Figs. 1 and 2.)

(*b*) *Stem symptoms.*—Irregular, raised, firm, discoloured blotches occur on the twigs, usually of a dirty-grey colour, and conspicuous on the still green bark. (Plate VII., Fig 1.) These blotches may either be isolated with slightly raised dark margins, or continuous in long lines, and studded with the minute dark pustules. The spotted dead brown portion of the twig becomes sharply marked off from the still living and green portion by a raised ridge round the twig, where the sunken dead tissue adjoins the still living tissue. If the shoots die from the tip downwards, and the greyish blotches show the minute black pustules (Plate VII., Fig. 2), there is every probability of its being this disease.

(*c*) *Fruit symptoms.*—The fruit is largely covered, usually on one side, with numerous brownish to blackish scabby patches, frequently run together, and cracking up into numerous small areas, from which thin flakes are constantly being detached. It has been already noticed in connexion with fruit-scabbing. (Plate VIII., Fig. 1.)

*Conditions favouring disease.*—I have always found that the trees attacked were in a languishing condition, and had their vitality impaired from other causes, probably from an insufficient supply of water at the proper time. This disease may attack insufficiently nourished trees even in a dry season, but, under similar climatic conditions, I have not met with it in well-irrigated groves.

*Cause.*—It is caused by a species of *Phoma,* but, like many other fungi, this one has different stages, so unlike each other that they have often received different names.

If one of the greyish or fawn-coloured blisters on the under surface of the leaf is examined, it is found that the filaments of a fungus ramify beneath the epidermis, and the tissue may still be green.

From these creeping filaments there arise others which pass through the stomata in tufts, and bear at or near their tips the minute reproductive bodies technically called conidia, which are capable of reproducing this stage of the disease on another portion of the same tree or on another tree. The very minute tufts can be seen, with the aid of a magnifying-glass, on the surface of the blister, and this is known as the *Cladosporium* stage. At a different part of the blister, and it may be at the same time, very minute dot-like pustules are seen imbedded in the substance, and on examination with the microscope are seen to be little capsules or perithecia, containing innumerable very minute colourless sporules. One can hardly realize the number of sporules contained in a single perithecium until he has watched, as I have done, the process of emptying when mounted in water. They are poured forth from an orifice in a constant and rapid stream, and this rate is kept up for a considerable time, when it begins to slacken somewhat and become jerky. Then a regular rush may take place, and finally they may proceed in single file. I have watched this going on for 35 minutes, when it ceased, and an immense number of hyaline sporules with a greenish tint in the mass were spread out before me. These sporules probably carry the fungus over the very dry season, and then reproduce it later on.

*Treatment.*—I have not had an opportunity of carrying out definite experiments in the treatment of this disease, but from its nature and the cause of it, allied somewhat to Anthracnose, the following suggestions may be given :—

1. Encourage healthy root action by a proper supply of nourishment and water.
2. Stimulate leaf and stem action by applying sulphate of iron dissolved in water to the ground around each tree. One or two pounds may be dissolved in a wooden vessel and given to each tree.
3. Carefully remove and burn affected twigs.
4. Spray as for Anthracnose.

### References.

Cobb (N. A.)—"Letters on Diseases of Plants." *Ag. Gaz.*, N.S.W., vol. VIII., pt. 4, p. 229 (1897). [Dieback simply referred to.]

Tryon (H.)—"Report of the Entomologist." Ann. Rep., Dept. of Ag., Queensland, 1897–8.

## PLATE IX.

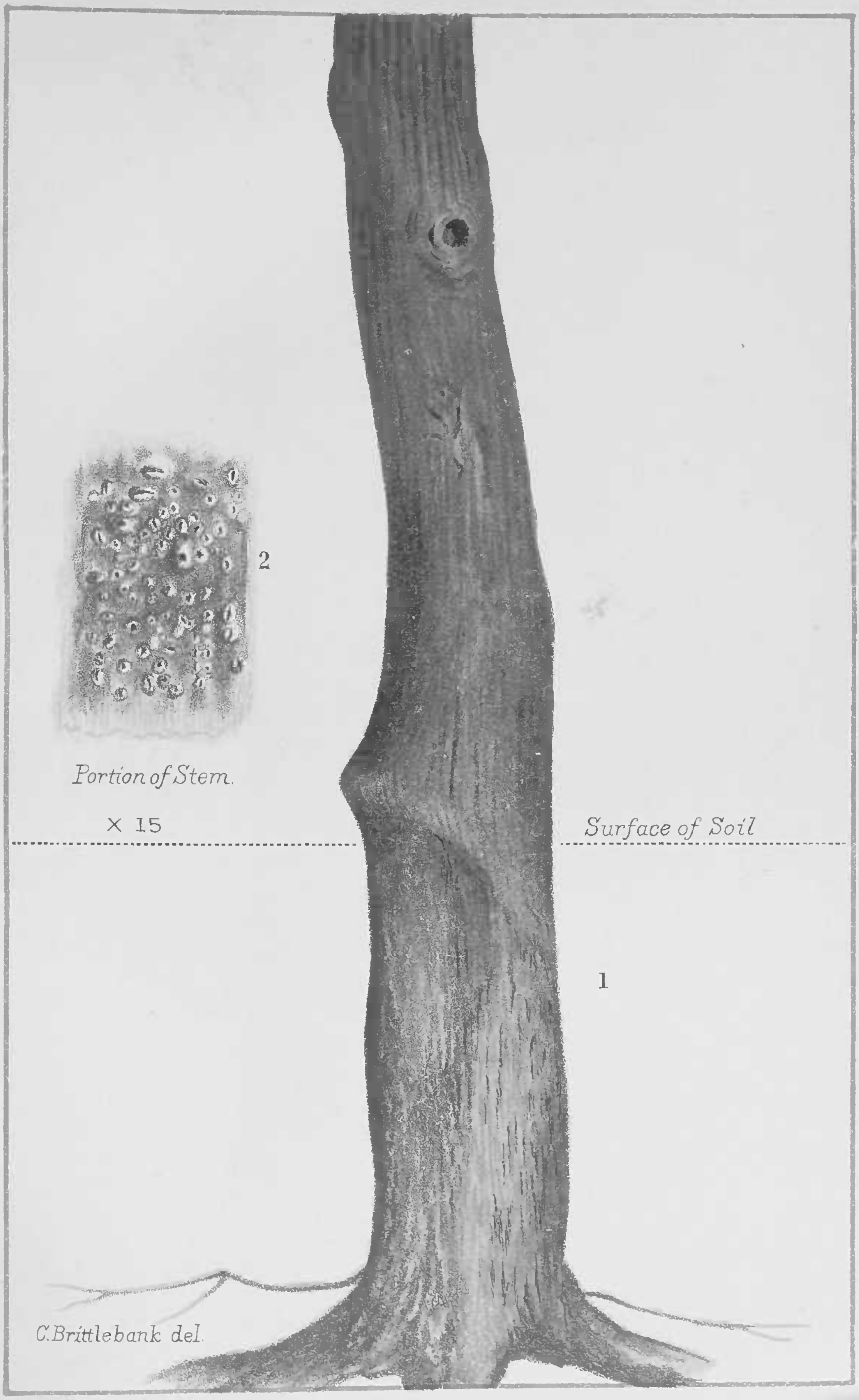
Lemon Bark Blotch (*Ascochyta corticola*).

Fig.

1. Lemon stem showing an early stage of the disease (nat. size).

2. Diseased portion of stem a little above the surface of the ground (indicated by horizontal line), showing the numerous pustules of the fungus slightly elevating the ruptured epidermis ( × 15).

PLATE IX.



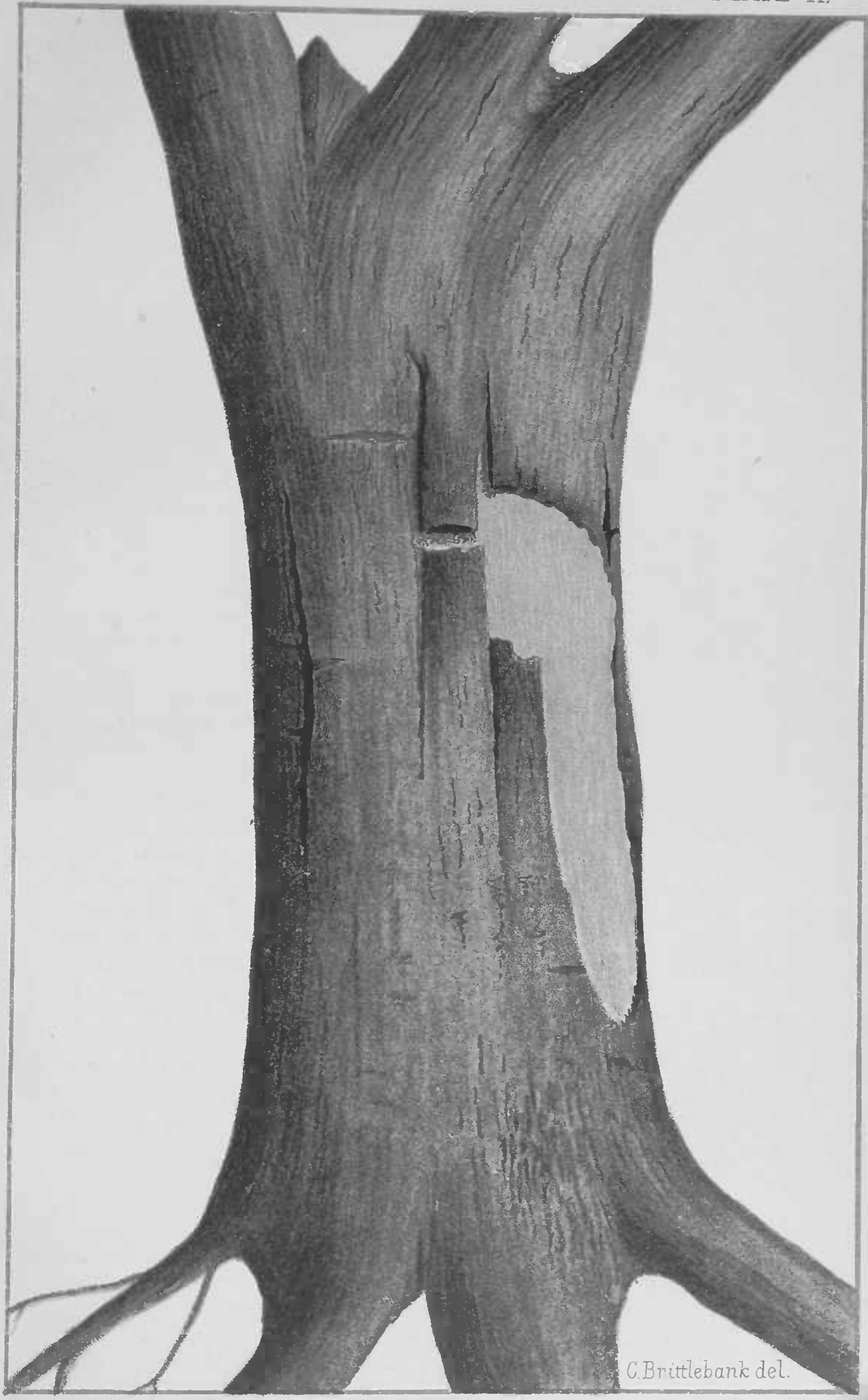
# PLATE X.

LEMON BARK BLOTCH (*Ascochyta corticola*).

Fig.

1. Trunk of Lemon tree, grown at Ardmona, showing how the bark is ruptured and ultimately destroyed by the fungus (nearly nat. size).

PLATE X.



## LEMON BARK BLOTCH.

(*Ascochyta corticola*, n. sp.)

*Symptoms.*—On 30th September, 1897, a grower in the Goulburn Valley wrote as follows :—"I am sending you a Lemon tree, to see if you can make out the cause of the trees dying. You will see that the bark of the tree is gone black about 6 inches from the ground. Its first appearance is a black spot, then it works all round the tree, and the tree dies. There are a great many trees affected in the orchard in the same way." (Plate IX., Fig. 1.)

*Cause.*—From the collar upwards, for about 6 or 8 inches, the stem was found to be shrivelled, and studded with little brownish thickly-clustered punctiform bodies, which burst through and slightly elevated the epidermis or corky layer. (Plate IX., Fig 2.)

Each little pustule represented a spore case, and contained innumerable microscopic colourless spores. This fungus was found to be *Ascochyta corticola, n. sp.* The trees were not planted too deeply, and they were carefully cultivated, but there had been two successive dry seasons in the district.

While visiting the district in the same month of 1898, I found a Lemon tree dying, or dead, about 15 miles distant from the first orchard (Plate X.). On the stem there were several different fungi, and the question arose as to which was the primary cause of the disease. On examining the stem near the collar, I found a species of *Gibberella*, and, thinking this might possibly be a complete stage of *Ascochyta*, I examined a portion of the stem higher up, and found *Ascochyta corticola,* the same as in the first specimen. The pustules of Gibberella and Ascochyta were similar to the naked eye, only the latter were a little higher up the stem. Later, I found a species of *Fusarium* associated with these fungi, which produced conidia, or naked spores. It is well known that a large number of fungi pass through different stages in the course of their life, some of which are so unlike each other that they were formerly regarded as distinct species, and named accordingly. Now, this may be merely a case of association, and not of genetic connexion, which can only be certainly proved by means of cultures ; but there are similar cases which give support to the conclusion that there is genetic connexion, that the one is a stage in the life history of the other.

The "Strawberry Leaf Spot" is only too well known in these colonies, and it is due to a fungus known as *Sphaerella fragariae* Sacc. *Sphaerella* would represent Gibberella, the one merely having uni-septate spores, the other having three, or multi-septate spores. As the result of experiment, Dr. P Voglino has found that the summer conidia-bearing form of the Strawberry fungus (*Ramularia*) may give rise to a pycnidial form (*Ascochyta*), succeeded by the complete form, *Sphaerella*. There is a striking resemblance between the two cases, and a comparison might be made thus :—

*Strawberry Leaf Blight.*

1. Ramularia tulasnei Sacc.—Conidial stage.
2. Ascochyta fragariae Sacc.—Pycnidial stage.
3. Sphaerella fragariae (Sacc.)—Ascomycetal stage.

*Lemon Bark Blotch.*

1. Fusarium incarnatum (Desm.).
2. Ascochyta corticola.
3. Gibberella pulicaris (Fr.).

So that in all probability the different fungi are merely stages in the life of one form, and the nature of the season, combined with the condition of the tree, will determine the particular stage which will prevail.

The tree in question bore a very heavy crop before dying right out, and the bark near the surface of the ground was ruptured and partially destroyed, not unlike the effects of "Collar rot" (Plate X.). The disease is evidently spreading, as this grower writes under date 11th April, 1899 :—"I am sorry to say I have two more trees dying off with the same complaint. The leaves in some cases are dropping off, the othors are drying up. Tho branches have a dark look, as if affected badly with scale. The bark is going at the graft. All the Lemon trees had night-soil trenched around them when they were planted; since then they have had mulching of stable manure."

*Treatment.*—As is the case with so many diseases of the bark of Citrus trees, if the affected portion is completely removed in the early stages of the trouble the wound soon heals, and health is restored. By this means the present disease was overcome when taken in time, but if allowed to go too far, the tree is practically ring-barked, and death ensues. Similar treatment to that of "Collar rot" may be recommended.

Although the disease has only been recorded from a few districts, it may, nevertheless, be more widely distributed. It has been confounded by some growers with collar rot, and the results are practically the same, but without the copious gumming as in that disease.

## PLATES XI. AND XII.

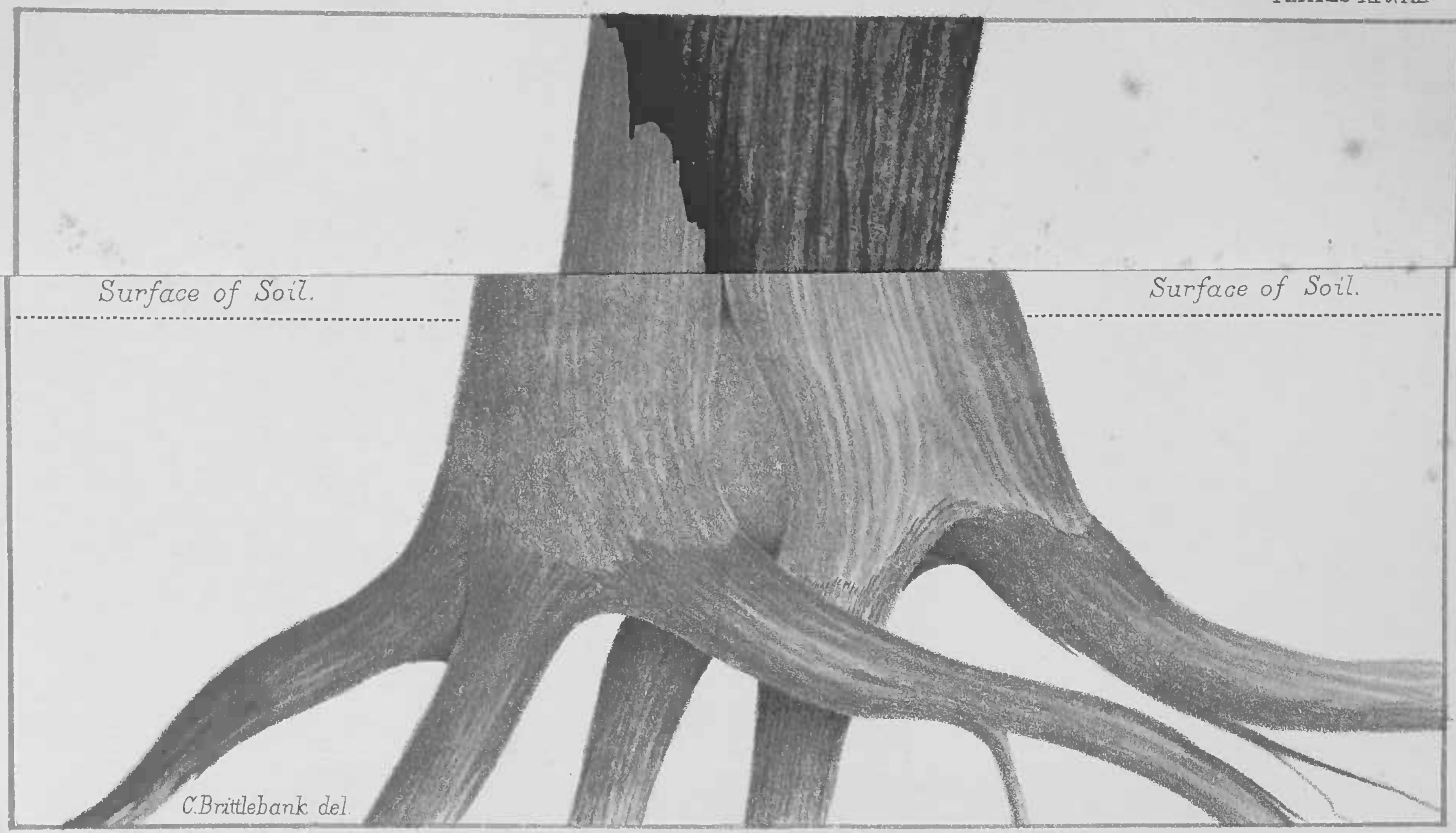
"Collar Rot" (*Fusarium limonis*).

Fig.

1. Stem of Lemon showing effects of collar rot. This disease begins at or a little beneath the surface of the ground, and is accompanied by copious gumming. This tree was about four years old, and bore an abundant crop of fruit, but it was evidently far gone with disease.

A little above the surface of the ground (indicated by a horizontal line) the bark not yet destroyed was seen to be much cracked, and pale straw-coloured masses of the fungus adjoined the cracks (nearly nat. size).

PLATES XI & XII.



## "COLLAR ROT" OR "MAL DI GOMMA."

(*Fusarium limonis.* Briosi.)

This disease being so widespread, has naturally a variety of names, and it is necessary to know the principal ones in order to understand the references made to it in various publications. It is commonly called "Collar rot," because it attacks the lower portion of the stem near the ground, and may either be below or above it. "Foot rot" has a similar signification, and the common Italian name of "Mal di gomma," or gum disease, indicates that gumming is a constant accompaniment of the disease. It is sometimes referred to as the fatal "Bark disease," but as several different diseases may be included under this term, it ought to be discarded. It is also known as "Sore shin" and "Bark rot," from the part affected, "The Fatal" from its destructive character, and the "Sydney disease" from being so common about Sydney; but the common name with us is "Collar rot." It is, unfortunately, one of the best known of Citrus diseases, for it occurs wherever Oranges and Lemons are grown, often causing serious loss. The first mention of it was in connexion with the Orange groves of the Azores, where it seems to have originated, and was noticed as early as 1832. Like many other diseases, it attained its maximum, then began to decline, and about 40 years afterwards its force was spent, and it ceased to be regarded as serious.

Meanwhile, it spread to Southern Europe, and afterwards appeared in Florida and California. It has now obtained a footing in Australia, and annually causes considerable loss. From the very nature of the disease, which attacks young and old trees alike, and may sometimes "ring-bark" them in the course of a few months, entire groves are either destroyed or rendered almost worthless. It is generally spoken of as a mysterious disease, but the discovery of the parasitic fungus causing it has brought it within the domain of rational treatment.

*Symptoms.*—The disease has often made considerable progress before the grower is aware of its presence, because it begins so low down that it is overlooked. One of the first indications is the exudation of drops of gum at the neck of the tree, and this is so constant that where there is no gumming some other disease is at work. It would appear that the fungus parasite excites the flow of gum for its own convenience, for I found numerous conidia actively germinating in it and producing filaments at either end or laterally. The gumming may occur at one or more spots, and the bark at the same time becomes discoloured. The browning of the bark is the sign of rotting which gives rise to a decidedly disagreeable odour, and the bark gradually rots away and is thrown off. If the tree is able to renew the bark and arrest the progress of the disease further mischief is prevented, but usually the disease runs the following course:—The cambium layer, which lies between the wood and the bark, is the formative portion of the stem, giving rise to new wood on the inside and fresh bark on the outside, and containing the necessary elements for building up. The object of the parasite seems to be to reach this treasure-house, and accordingly the decay reaches the cambium layer and even extends into the wood. When this happens there is no possibility of the renewal of the bark, and that portion is dead. Then the disease spreads further in all directions, principally around the base of the stem and down to the main roots. Gradually the diseased area is extended, the tree is completely girdled, and death ensues. While this is taking place near or beneath the ground, the foliage is affected and becomes yellow and sickly from the insufficient supply of nourishment from the roots.

The exudation of gum at the collar, the decay of the bark there in patches, and the consequent disagreeable odour, the unhealthy appearance of the foliage, and the death of the small shoots are all symptoms of this disease.

Mr. Williams, of Doncaster, who has been growing Oranges and Lemons for a number of years, says that—"Generally, the first visible intimation of the disease is the fruit setting abnormally thick, and the foliage turning a sickly yellow colour." This fruit-setting is an evident effort of the tree to provide successors before it finally perishes.

*Effects.*—This is regarded as the most destructive of Citrus diseases, as it is also one of the most widespread. I have no means of estimating the loss caused by it in Australia, but in Florida the annual damage is calculated to be about £20,000; and in Italy, taking an average of sixteen years, there is a loss of £25,000. Under ordinary circumstances affected trees gradually die off, but sometimes the wound heals of its own accord. When trees are attacked, they may produce an extra large crop of fruit the first season, but this is usually the expiring effort, and little or none is produced afterwards. In a few months the "ring-barking" of the stem may be almost completed, and as the disease spreads from tree to tree, in the course of a few years entire orchards may be devastated. The progress of the disease will be rapid or slow, according as the conditions favour it or otherwise.

The healthy root action is interfered with, and there is a deficiency of nourishment, the foliage is affected and is unable to assimilate properly, the girdling of the stem prevents that free communication between root and leaf which is essential to plant growth, and, finally, with the destruction of the cambium layer, the centre of vital activity, the tree is doomed.

*Conditions favouring Disease.*—The conditions which favour the disease are often confounded with the cause, but we must distinguish between them. There are what may be called predisposing causes, conditions which affect the plant injuriously and render it liable to the attack of the fungus parasite. They may be guilty of aiding and abetting and preparing the way for the fungus, but of themselves do not induce the special disease known as "Collar rot." As far as known, it is necessary that this particular fungus invade the weakened tissue in order to produce the characteristic symptoms which we speak of as the disease, and whatever is antagonistic to these conditions or destructive of this fungus will tend in the direction of preventing or remedying the disease. Unsuitable soil is said by some to produce the disease, because it always occurs towards the base of the stem, near to or beneath the surface of the soil; but transplanting the trees to similar soil may lead to their recovery. Sudden changes in the temperature of the soil surrounding the stem are also supposed to induce it, the sudden and extreme variations affecting the regular flow of the sap and producing contraction and expansion of the bark.

The want of proper drainage is likewise a contributing condition, because it will prevent the perfect aeration of the roots, and the water may be allowed to lodge round the stems.

Close and deep planting, producing an excess of shade and a deficiency of feeding roots; excessive irrigation, keeping the soil soaked with water; excessive cultivation, which may tend to injure and disturb the roots; and the continuous use of organic fertilizers are all said to encourage the disease.

Propagation by grafting is also found to render the tree susceptible at the junction of the scion and stock, and, as will be shown more fully later, certain varieties and certain stocks are found to be highly resistant to the disease.

It is very generally stated that the use of Lemon stocks renders the tree specially liable to this disease, but Mr. Tryon finds that trees on Orange stocks are equally liable as far as the Toowoomba district is concerned.

*Cause.*—The cause of this disease is still in dispute, but the contagious nature of it seems to point to some parasitic organism. In 1878 Briosi described a fungus which he always found accompanying the disease, and named it *Fusarium limonis.* He was inclined to regard it as the cause of the disease, but had not sufficient evidence to prove it. He adds, however—"I do not believe there can be any doubt that its presence accelerates the disorganization of the tissues and aids in extending the disease."

I have invariably found the same fungus penetrating the diseased tissues with its long slender wandering filaments, and being found here as well as in Italy strengthens the belief that it causes the disease.

The way in which the disease begins in spots or patches, which slowly enlarge, the gradual manner in which it spreads from country to country and from grove to grove, the fact that transplanting affected trees from crowded situations to more open localities has brought about recovery, and the appearance of the same fungus associated with it in such widely remote countries as Italy and Australia, all point to the conclusion that this fungus parasite is the immediate cause of the disease. Of course, too much moisture around the roots would favour the growth of the fungus, and so trees with "wet feet" would be specially liable to the disease; but it is highly improbable that such a contagious disease, and one which has been checked by the application of fungicides, should be due to some physiological derangement or merely mechanical causes. Dr. Cobb, in his useful *Letters on Diseases of Plants*, refers to a fungus which he found upon the diseased bark of a young Orange stock, and which he considered to be a case of apparent "Collar rot"; but there was no evidence of gumming, a constant accompaniment of the disease. The fungus is not fully described or named, and drawings only are given; but it is evidently a species of *Phoma*. If an undoubted case of the disease is chosen, the "Collar rot" fungus (*Fusarium limonis*) will be found there. The specimen from which the fungus drawings were made was obtained at Doncaster on 28th August, 1896, and the coloured plate represents the stem of a Lemon tree obtained at Malvern. The effects of the "rot" were visible for at least 6 inches from the ground, and they extended to some of the roots, which were quite dead; but there was nothing to indicate that the disease had started at the roots (as is the opinion of some) and then spread to the stem. The disease had apparently started just beneath the surface, and spread upwards along the stem and downwards along some of the roots.

There is a totally distinct disease, known as "Root rot," which is often confounded with "Collar rot," commencing at or near the extremities of the roots and proceeding upwards until the tree is killed. The malady is due to quite a different cause, and will be discussed afterwards.

*How the disease may be spread.*—If the gum exuding from an affected tree is examined it is found to contain innumerable reproductive bodies of the fungus, or *conidia* as they are technically termed. And not only so, but these bodies are actively germinating, and so capable of growing on any suitable medium and reproducing a similar fungus to that from which they originated. Suppose a little portion of this gum containing these conidia at the stage when they are ready to germinate is conveyed by any means to a citrus tree under favorable conditions for the growth of the fungus, then we may expect that the disease will appear. It is thus highly probable that the tools used for purpose of cultivation may carry the germs of the disease from infected to healthy trees, or from diseased to healthy groves. Besides, the gum may act as a preservative for the conidia, and thus prolong their vital activity. During irrigation, gum with conidia might easily be carried from diseased to healthy trees, more especially when the water is allowed to flood up to the trees. It is not maintained that this is the only way in which the disease is spread, but it is sufficiently evident to be worthy of being guarded against.

*Varieties affected.*—I am not aware that any particular varieties have been specially noted in Australia as being affected with this disease, further than that it has been observed on oranges and lemons. But in Florida the susceptibility of different kinds has been carefully observed. The most susceptible appears to be sweet seedling orange trees (*Citrus aurantium*), and stocks of this used for budding are also liable. Then the lemon (*Citrus limonum*) in all its varieties is very commonly affected, but the Shaddock (*Citrus decumana*) is less liable to the disease than either of the two preceding. Mandarin oranges (*Citrus nobilis*) are only occasionally affected, and the Seville or bitter orange (*Citrus bigaradia*) is the least susceptible of any, being almost entirely free from it. This points to the use of the sour orange as a stock for budding, and Swingle and Webber write :—"The sour (Seville or bitter) orange, used as a stock for budding, remains free from attacks, and in Florida its use for this purpose is almost a sure preventive of the disease." The liability or non-liability to disease is a matter requiring to be tested in different localities with their varying conditions of soil and climate, so that the order of resistance in Florida does not necessarily imply a similar resistance in Australia. It is to be hoped that experimental tests will settle the best and most suitable varieties to be used in different districts of Australia.

*History of disease in Australia.*—In the evidence given by C. Moore, F.L.S., late director of the Botanic Gardens, Sydney. before the Victorian Royal Commission on Vegetable Products, he stated that this disease was very destructive to the oranges about Sydney as far back as 1867. Then the late Mr. Neilson, curator of the Royal Horticultural Gardens, Burnley, gave evidence that he had experience in the gardens of what is known as the Sydney disease, and recommended the following means of dealing with it :—"I have come to the conclusion, as far as I am concerned, personally, that in a great measure it is attributable to deep planting. In planting the orange now, I keep the tap roots upon the surface, and all that I have used in that method I have never found the slightest symptoms of decay. Another cause I think is in watering—in putting the cold water upon a very hot day close to the bark of the tree, that causes sudden evaporation, which chills the bark; that is the reason that I assign in a great measure for it. In irrigating the orange tree, it should never go within 3 feet of the bark." Mr. G. W. Knight, nurseryman, at Bendigo, also stated before the Commission that he had an avenue of limes about 14 or 15 feet high entirely destroyed by this disease. He then commenced to grow lemons grafted on the Seville orange to replace these, and they are reported as being healthy, strong, and vigorous, without any evident sign of disease. Mr. E. H. Acres, of Heywood orchard, near Parramatta, experienced this disease some 25 or 30 years ago, (speaking in 1888), and claims to have checked it. He was asked the question—There is a disease known in Victoria as the Sydney disease or bark rot; what is the cause of it ? and he replied—" It arises from too much moisture round the roots of the tree, and yet there is such a thing as overdraining the ground. I have seen orchards in which owners have gone to great expense in draining, and have done too much. About 25 or 30 years ago I noticed the trees just showed the disease at the surface, and sometimes down the roots. I had been reading something about the effects of lime, and I told one of the men to scrape away the decayed part of the bark and treat it with stone lime mixed to the consistency of dough. This was done, and it seemed to stop the disease."

Mr. Skene, nurseryman and fruit-grower of the Mildura settlement, who had thirteen years' experience of orange-growing in Florida, and had then been two years at Mildura, attributed this disease chiefly to deep planting, and claimed to have cured many trees by lifting them up, letting the air get round them, and applying some lime.

In Queensland this disease has been known at least as far back as 1876, for the report of a board appointed to "inquire into the causes of diseases affecting live stock and plants," published in 1876, contains the following :—" The orange family suffer occasionally from a disease of the bark near the root ; a gummy secretion exudes and the tree dies. This happens occasionally after a slight bruise from a gardener's tool. The disease has not been carefully examined."

It appears, however, that the disease has not as yet caused much trouble there, for Mr. Corrie states, in his address at the New Zealand Conference of Australasian Fruit-growers that—" The very serious bark diseases, and forms of collar- and root-rot which have wrought such devastation in some of the old world groves, so far, have not caused much anxiety in Queensland, and such fungus diseases as exist cannot be said to have interfered with the industry."

*Treatment.*—This will be based upon a knowledge of the immediate cause of the disease—in this case a fungus—and of those favouring conditions which have been found by experience to predispose or render the trees susceptible.

1. There is a general remedy which has been found applicable to citrus trees affected with diseases due to fungi, and that is to cut away the diseased portion, taking care to remove every trace of it, and, to make sure, a little of the apparently healthy tissue surrounding it as well. This has been found successful in bark diseases generally, and of course every such diseased portion should be burnt. The wound will generally heal, and the further progress of the disease be stayed.

2. In order to prevent infection from stray conidia or from filaments of the fungus which may still be in the surrounding tissue without external signs, some antiseptic solution should be used to dress the wound.

(*a*) Mr. W S. Williams has found that painting with *carbolic and olive oils* mixed in equal proportions, will prevent any further extension of the disease.

As the result of the Florida experiments the following solutions are also recommended :—

(*b*) *Sulphurous acid*, in the proportion of 15 to 85 parts of water. This may be used to wash or paint the wound, or it may be sprayed on the exposed roots.

(*c*) *Carbolic acid*, in the proportion of 1 part of crude acid to 1 part of water. This may be used to paint the wound or sprayed on the roots when diluted in the proportion of 1 to 5.

(*d*) *Sulphur wash.* This is a generally useful preparation, and consists of flowers of sulphur and caustic soda. To make a stock solution, place 30 lbs. of flowers of sulphur in a wooden vessel and mix it with sufficient water (about 12 quarts) to make a stiff paste. Add to this 20 lbs. of finely powdered caustic soda, and mix thoroughly by vigorous stirring. The mass becomes hot, turns brown, boils, and liquefies in a few moments. When the violent boiling has ceased, add water to bring it up to 20 gallons, and strain into a barrel which can be kept tightly corked.

| | | |
|---|---|---|
| Formula— | Flowers of sulphur ... ... | 30 lbs. |
| | Caustic soda (NaHo) ... | 20 lbs. |
| | Water ... ... ... | 20 gallons |

For covering wounds 1 part of this stock solution is to be added to 1 part of water, and for spraying the roots 1 part to 10 of water.

Even coal tar has been used as a dressing.

3. As imperfect drainage prevents the proper aeration of the soil, and as this seems to favour the development of the fungus, the removal of the soil and the *exposure of the roots* to the air

will often of itself prove effectual. In removing the soil care should be taken not to injure the healthy roots, and a few pounds of slaked lime might be applied.

Proper drainage of the soil is thus a good preventive of the disease.

4. As highly *nitrogenous organic manures* seem to encourage the fungus or predispose the tree to its attacks, avoid them.

5. Avoid *close planting*, as the excessive shade thus produced is favorable to the fungus, apart from its injurious effect upon the trees.

6. *Transplanting* badly affected trees and giving them plenty of room has also been found beneficial.

7. Avoid *deep ploughing* close to the tree, as the roots are thereby often injured and the entrance of the parasitic fungus encouraged.

8. It has been found as a matter of practical experience that *budded plants* are less liable to the disease than grafted ones. The union of stock and scion in a graft is nearer the base where it is liable to be attacked than in budded plants, and the disease often occurs just at the junction. Besides budding makes a firmer union with the stock, and is both easier and quicker. Therefore budded are to be preferred to grafted trees, and layering seems to be best of all.

9. Generally speaking, whatever encourages the healthy growth of the trees should be attended to, and whatever weakens their vitality should be avoided. As citrus trees are very sensitive to water lodging at the roots irrigation should be used in moderation, and if water is allowed to flood the whole surface the germs of the disease may readily be transferred from one tree to another, and the drainage should be good, in order to provide for the perfect aeration and the equalization of the temperature of the soil. Deep planting and deep cultivation should be avoided, and too close planting prevents the free access of light and the proper development of feeding roots.

In order to get the best possible local experience, I addressed a few questions to one of our most successful citrus-growers in the Doncaster district, Mr. F. Finger, and in returning the answers he made the following remark—"With regard to the 'Collar Rot,' I have been very lucky. I have not lost one tree with it yet, although I have had several affected, but they grew out of it. My oldest trees are on sweet orange stocks, and a lot of my younger ones are on bitter orange stocks. I have none on lemon stocks. I plant only layers now, as they have no union, and they are not so liable to get the 'Collar Rot.' In fact, I have never seen any signs of the disease on them yet. They grow much quicker and bear finer fruit than seedlings."

The questions and answers are here given :—

1. At what age have you found trees attacked ?—I have seen trees two years from the nursery affected and die from the "Collar Rot."

2. Is the lemon more liable to the disease than the orange ?—From my experience in what I have seen the lemon stock is most decidedly more subject to the disease.

3. Do affected trees bear an abnormal amount of fruit the first season ?—Yes, they do, and that is a pretty sure sign of the disease if the tree is about five or six years old.

4. Do you approve of the lemon stock for oranges ?—I, myself, would rather have lemon on lemon and orange on orange stocks. It depends on the climate and soil.

5. What is your opinion of the bitter orange stock as a preventive against "Collar Rot" ?—I don't think it is as good as the sweet orange.

6. Have you had sufficient experience of layering to say if it will have any effect on "Collar Rot" ?—I have never seen a sign of "Collar Rot" on layers, but they might get it in favorable places.

7. Some say that they do not like layering as well as working on seedlings, what is your opinion ?—I intend in future to plant only layers.

8. Is there any other information you wish to give ?—The main point is to have good drainage, and don't plant the trees too deep, and keep plenty of moisture around them in summer time.

As regards layering opinions are much divided, and it has been stated that layering has been abandoned in New South Wales owing to such trees being subject to collar-rot.

## References.

Since the discovery of the disease in 1832 numerous observations have been made upon it, and in the literature of this disease alone, given in Dr. Penzig's work already referred to, no less than 54 publications are mentioned. Even in Australian publications there are numerous references to it.

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## ROOT-ROT OF LEMON.

(*Phoma omnivora*, n. sp.)

It is only quite recently that I have had an opportunity of examining this disease, as it has probably hitherto been confounded with "Collar-rot." The first mention of it, as far as known to me, is by Mr. W. S. Williams, of Doncaster, who referred to it at the Conference of Australasian Fruit-growers, held at Brisbane, in 1897, in the following terms:—"This disease is of a more deadly character than Collar-rot, as it begins in the subsoil at the extremities of the roots, and proceeds upwards until the tree dies. Once a tree is affected there is no cure. The cause of this disease is bad drainage and stagnant water, which poisons the roots; or it may also be caused by some deleterious substance in the subsoil, such as salt, copper, antimony, or other poisonous minerals. Many people mistake it for collar-rot, but they are totally different in their symptoms, and brought on by totally different causes."

*Symptoms and effects.*—The trunk and main roots of a Lemon tree suffering from this disease were kindly forwarded to me by Mr. Williams for examination. The half-dead roots were seen to have lost the outer bark for a considerable distance, and the inner layer showed numerous pustules of *Phoma omnivora*. The colour of the diseased part was dark-brown, in parts almost black. On examining portions of the outer bark on the other side of the same roots, the fungus was also met with. On other roots, seemingly quite sound, there were small black patches seen to be due to the numerous pustules of the fungus, though at almost any part of the roots the fungus could be found on microscopical examination, not being visible to the naked eye. The earth and soil adhering to the roots in many cases hindered the discovery of the fungus, and of course its presence would not be suspected by the ordinary observer.

It was remarkable that the *Phoma* could be found on the roots at a depth of not less than 10 inches below the surface of the soil and extending all the way up the trunk, at least to the limit of the specimen sent, which was cut off fully 6 inches above the ground. Thus, allowing for the bend in the roots at junction with the trunk, a length of over 2 feet was attacked with greater or less severity by the fungus, and no roots were found entirely free from it.

On the side of the stem to which the decayed roots belonged, the bark rotted away as in the case of Collar-rot (but without the accompanying gumming), and this could easily be accounted for from the necessary nourishment not being supplied on that side. Mr. Williams had noticed this particular tree failing for a year or more, and he believes that the points of the roots went first.

*Other cases of Phoma on roots.*—There is a disease of Beet-root caused by *Phoma betae* (Frank), which attacks the young heart leaves and blackens them and extends thence into the roots. The mycelium or threads of the fungus spread from the diseased parts to the healthy tissues, and the little pustules are developed on these spots.

The Carrot is likewise attacked by a *Phoma* (*P. sanguinolenta Rostr.*) which causes depressions or canker-like spots on the roots, and on the diseased patches numerous dark-grey perithecia occur.

A Root-rot of the Cauliflower was brought under my notice some time ago by Mr. Molineux, of the Agricultural Bureau, South Australia, and it was found to be caused by *Phoma brassicae* (Thuem.). The roots often shrivelled and dried up, and in every instance the superficial tissue of the diseased roots showed the numerous black pustules of the fungus, which in this case never extended above ground.

These instances will show that a similar fungus to that of the Root-rot of the Lemon may pass down to the roots from above or be confined entirely to the parts underground.

*Cause of Disease.*—The mere occurrence of the fungus on dead or dying roots would be no proof of its parasitic nature, but having already been found to cause the death of parts above ground, it may be assumed to act similarly towards underground parts. This fungus has now been found on every portion of the tree—root, stem, branch, leaf, and fruit—and it may either pass downwards to the roots, or, agreeing with Mr. Williams' observations of the disease, beginning at the tips of the roots, exist in the soil and attack the roots there. This would explain many cases of so-called Collar-rot which were maintained to have started in the roots and travelled upwards to the collar.

*Treatment.*—Recognising the fungus as causing the disease, there are several precautions which may be taken to check it and prevent its spread.

1. Drainage should be attended to, as well as whatever encourages a strong and healthy growth. Deficient drainage is said to cause the Root-rot, and this in a sense is true, for stagnant water not only favours the spread of the fungus but renders the tree weak and liable to attack.

2. Cut well back in order to start a fresh growth, and see that all the portions removed are burnt, as they are probably affected with the fungus.

3. Destroy by burning all fallen leaves from diseased trees, as by means of fallen leaves the spores may get into the soil and infect the roots.

4. The addition of 2 lbs. of powdered sulphate of iron and an equal quantity of fresh slacked lime to the soil around the trunk might prove advantageous.

5. Small holes made with a stick, about 10 inches apart, from 6 to 30 inches round the tree, and Bordeaux Mixture poured in, at the rate of about half-a-gallon to each tree. A fortnight after about 3 lbs. of slack lime hoed in.

This method was brought under my notice by Mr. McClymont, of New South Wales, who applied it successfully to Emperor Mandarins, four years old.

The encouragement of a healthy growth by drainage and manure where necessary is the sovereign remedy. In bad cases the tree should be removed and burnt, and the soil disinfected before replanting. Wherever a tree has died from this cause it should not be allowed to remain and rot in the ground, and thus spread the disease in the soil, but be carefully rooted up and burnt.

# PART II.

# TECHNICAL DESCRIPTIONS OF FUNGI FOUND UPON CITRUS TREES.

The first part is devoted to a general account of the principal fungus diseases affecting Citrus trees in Australia, and will receive most attention at the hands of the practical grower, while this second part gives technical descriptions of all the fungi hitherto found upon them here, and will be welcomed by those who take an intelligent interest in the nature of the causes producing certain effects, as well as in the effects themselves.

It is necessary for inspectors and others who wish to be abreast of present day knowledge with regard to fungi in their relation to plants to know the various forms which may be met with, so as to discriminate between the really serious pests and those which are comparatively harmless or positively innocuous.

One of our most successful Citrus cultivators has recommended every grower to be provided with a magnifying glass to examine the trees and see the effect of any treatment applied to them, and it may be remarked that, for the proper study of fungus diseases, the microscope is indispensable. The Government, however, provides experts to do this work—to diagnose disease and prescribe the necessary treatment—but no one can tell exactly the cause in many cases without having recourse to microscopical examination. Professor Viala, of Montpellier Viticultural College, points out that diseases due to very different causes are often confounded as having the same origin. Opinions may have been formed upon the external characters of the injury, or upon simple facts of observation, while in specifying a disease external characters are only of secondary importance. It is doubtless useful to know these, but it is necessary first of all to define the alterations by their real cause, by the study of the parasite if the disease is of a parasitic nature. And even the undoubted presence of a parasite upon the affected part is not sufficient in itself to prove that the injury is caused by it. Experiment ought to confirm the facts of observation.

In the following pages the fungi are grouped according to their occurrence on fruit or leaf, on stem or root; but this arrangement has its drawbacks. Several of the fungi are found upon different parts of the tree, and the plan strictly followed out would involve needless repetition, but this is avoided by noting any such general appearance in connexion with the first mention of the fungus.

In bringing together the various fungi occurring on Citrus trees, their large number must strike even the casual reader, and of these a large proportion are not known in European countries considered to be the present home of Citrus fruits. But it must be remembered that for many years the Native Lemon has been almost universally employed as a stock in Queensland and New South Wales, and thence imported into Victoria, so that native diseases were probably introduced with it. It would be an interesting and useful investigation to determine the various diseases to which the Native Oranges and Lemons of Queensland are subject. In Professor Penzig's magnificent work with accompanying plates, constituting the Annals of Agriculture for 1887, and published for the Italian Department of Agriculture, no less than 190 different species of fungi are recorded as being found in Italy on Citrus trees, although, of course, a number of these are purely saprophyic.

So widespread is the demand for technical instruction at the present time, that it is customary, even in agricultural journals, to explain scientific terms, and an attempt is made here to make the meaning clear of the more commonly occurring terms necessary for brevity and exactness in a technical description.

## I. FUNGI ON FRUITS.

1. Capnodium citricolum.
2 Eurotium herbariorum.
3. Pyrenochaeta aurantii.
4. Monilia rosella.
5. Aspergillus glaucus.
6. Penicillium glaucum.
7. Penicillium italicum.
8. Ovularia aurantii.
9. Ovularia citri.
10. Cladosporium brunneo-atrum.
11. Cladosporium furfuraceum.
12. Cladosporium subfusoideum.
13. Sporodesmium griseum.
14. Coniothecium scabrum.
15. Fusarium epithele.
16. Phoma citricarpa.
17. Phoma omnivora.
18. Sphæropsis citricola.
19. Diplodia citricola.
20. Septoria depressa.
21. Bacteriosis.

### 1. SOOTY MOULD.

(*Capnodium citricolum*, McAlp.)

Forming black soot-like incrustations, peeling off as a thin membrane, often covering entire surface of leaf, also on fruit and branches.

Hyphae creeping, colourless to pale green, copiously branched, septate, 6–8$\mu$. broad, intertwining and forming a pavement of cells, with ascending short simple septate branches.

Conidia colourless or pale-green, continuous, 1–2—septate, spherical, oval, or elliptical, slightly constricted, smaller $7\frac{1}{2}$–$9\frac{1}{2} \times$ 4–$5\frac{1}{2}\mu$., larger 11–24 $\times$ $5\frac{1}{2}\mu$.; or in moniliform chains.

Coloured hyphae greenish-brown to dark-brown, closely septate, deeply or slightly constricted, sparingly or copiously branched, rigid, $9\frac{1}{2}$–$11\mu$. broad, bearing similarly coloured conidia, usually elliptical, uniseptate, $7\frac{1}{2}$–$16 \times 5\frac{1}{2}$–$8\frac{1}{2}\mu$.

Perithecia intermixed with various other reproductive bodies, sea-green to sage-green, appearing black, oblong to oval, or variously shaped, rounded and smooth at free end, 112–250 $\times$ 52–$112\mu$.

Asci cylindric-clavate, sub-sessile, apex rounded, 8–6 or 4—spored, 70–80 $\times$ 19–$20\mu$.

Sporidia brown, oblong, sometimes sub-fusoid, generally obtuse at both ends, constricted about the middle, 5–6 septate, often with longitudinal or oblique septa, arranged mostly in two rows but occasionally in three, averaging 21–24 $\times$ $8\frac{1}{2}$–$9\frac{1}{2}\mu$.

Paraphyses hyaline, finely granular, elongate-clavate, as long as asci, and $9\mu$. broad towards apex.

On living leaves of Orange and Lemon, particularly on upper surface, also on branches and fruit. All the year round. Victoria, New South Wales, South Australia, Queensland, and Western Australia. (Plate III., and Figs. 1, 2, 3, 4).

## 2. HERBARIUM MOULD.

(*Eurotium herbariorum*, Link.)

Perithecia seated on creeping, branched, interwoven, at first white, ultimately coloured filaments, spherical, bright sulphur-yellow, 150–$170\mu$. diam.

Asci spherical or sub-spherical, 15–$18\mu$.

Sporidia 8, crowded ; hyaline, lens-shaped, average $8\mu$. diam., with a groove around it, and briefly radiate-striate on each side.

On decaying Lemons. Victoria.

*Aspergillus glaucus* (Link) was found associated with it, this being the conidial stage. (Figs. 5, 6.)

## 3. ORANGE PYRENOCHAETA.

(*Pyrenochaeta aurantii*, n. sp.)

Forming small, black, rough patches towards base of Orange, and showing, when magnified, densely gregarious, black, globular perithecia with distinct pores, seated upon a grey and dark substratum intermixed.

Perithecia arising from a generally olive-green matrix, consisting of a close network of pallid moniliform filaments forming a pavement of cells, and stout olive-green, septate, branched filaments on top, averaging 7–8$\mu$. broad or more. Abundance of *Cladosporium*-like conidia are produced, and a few like those of *Macrosporium*.

Perithecia dark brown or olivaceous, firm, globular to elongated-globose, with scattered spines particularly towards apex and surrounding wide mouth, 75–112$\mu$. diam., and mouth up to between 50 and 60$\mu$. diam.; spines rigid, brown, blunt at apex, usually bulging about middle, and narrower and more transparent towards base, continuous, 19–26 × 4–5½$\mu$.

Sporules minute, hyaline, spherical, held together by mucilage, 2–2½$\mu$. diam.

Growing on Orange with False Melanose. July, 1898. New South Wales.

This species was only found on a limited area of one Orange, although a number were carefully examined, so that it does not seem to be common as yet. (Figs. 7, 8, 9, 10, and 185.)

## 4. PINK MONILIA.

(*Monilia rosella*, n. sp.)

Forming pale-pink effused patches, up to ¼ inch, at first covered by slightly raised membranaceous cuticle, then free.

Sterile hyphae, pinkish collectively, hyaline individually, densely fasciculate and interlaced, septate, much branched, varying in thickness and often suddenly narrowing, 6–15$\mu$. broad.

Fertile hyphae septate, sparingly branched, average 2–3$\mu$. broad.

Conidia in chains, readily detached, hyaline to yellowish, elliptic, 6–9 × 3–4$\mu$. (stained as well as the hyphae greenish-yellow by potassium-iodide-iodine).

On decaying Lemons, also largely covered by *Penicillium*. November 1898. Stawell, Victoria.

This species forms very striking pale-pink patches, and the cuticle covering it at first is wrinkled and papery. I have placed it in the genus *Monilia* rather than *Oospora* on account of the copious development of mycelium. *Oospora fasciculata* Sacc. and Vogl. found on decaying Oranges is quite distinct both in the colour of the mycelium and of the conidia. (Figs. 11, 12.)

## 5. BLUE MOULD.

(*Aspergillus glaucus*, Link.)

On Lemon, from Wandin Yallock, Victoria.

Conidia globose, slightly asperulate, hyaline, then glaucous, average 8$\mu$. diameter.

## 6. MOULDY ROT OR BLUE-GREEN MOULD.

(*Penicillium glaucum*, Link.)

On decaying Oranges and Lemons. Common.

## 7 MOULDY ROT.

(*Penicillium italicum*, Wehmer.)

On decaying Oranges, Victoria.

This species resembles *P. glaucum*, but the spores are ellipsoid, and average $4 \times 2\frac{1}{2}\mu$.

## 8. GREYISH-GREEN OVULARIA.

(*Ovularia aurantii*, n. sp.)

Erumpent, forming effused greyish-green patches on Orange which has become of a uniform continuous dark-ruddy brown, over one-half or more of its surface.

Hyphae standing out, short, simple, septate, tapering towards apex where conidia are produced, $2\frac{1}{2}$–$3\mu$. broad.

Conidia colourless, generally cylindrical and straight, rounded at both ends, sometimes gradually tapering towards one end with granular contents, $13–15 \times 3–3\frac{1}{2}\mu$.

On Oranges imported from Italy. March, 1899.

The dark ruddy-brown discoloration of the Orange is first noticed, then the erumpent greyish-green effused patches of the fungus on the discoloured portions. It is distinguished from *Ramularia* by the conidia never being septate. Occasionally they appear to be 1-septate, but the appearance is due to the division of the protoplasm into two parts. Ovularia has not hitherto been recorded on any of the Citrus species. (Figs. 13, 14.)

## 9. RUDDY-BROWN SCAB.

(*Ovularia citri*, n. sp.)

"Scabs" of a pale ruddy-brown, sometimes isolated, but usually run together, and covered with a fine whitish coat of mould.

Hyphae hyaline, but tinted in the substance of the "scab," slender, slightly sinuous, septate, branched, and much interwoven, branches often at right angles, often vacuolated, and with finely granular contents, $1–2\mu$. broad.

Conidia terminal, on projecting hyphae, at first colourless, then pale yellowish, nearly globular to slightly elliptical, about $5\mu$. diameter, or $3–4 \times 2\mu$.

On ripe Lemons, imported into South Australia from New South Wales, September, 1898 (Quinn).

The Lemons are sometimes rough all over with the hard excrescences, and thereby rendered unsaleable.

The solitary continuous conidia indicate that this form approaches nearest to *Ovularia*. The vegetative phase is most abundant, at least at this season of the year, and conidia are not copiously produced. (Figs. 15, 16.)

## 10. FALSE MELANOSE.

(*Cladosporium brunneo-atrum*, n. sp.)

Mycelium composed of a network of creeping hyphae of a greyish or greenish colour, and ultimately olivaceous, septate, constricted at septa, much branched, and branches often at right angles, average $5\frac{1}{2}$–$6\frac{1}{2}\mu$. broad, reaching $8\mu$.

Conidia produced at or near the apex of short, septate, projecting conidiophores, and similarly coloured at first, finally becoming brown, globose to elliptical, mostly simple, but also uniseptate, smooth, 8–10 × $5$–$7\frac{1}{2}\mu$., or $6\frac{1}{2}$–$7\frac{1}{2}\mu$. diameter. On Oranges. July, 1898. Sydney, New South Wales.

This is the cause of the so-called "Melanose" of Australia, which is simply one form of "scab." The brown spots, or blotches, ultimately become blackish, and split up into numerous small areas, from the hyphae bursting through to produce their conidia. The conidia are at first colourless, ultimately almost chestnut-brown, and for the most part unicellular.

It differs from *C. sphaerospermum* (Penzig) in the short, closely septate conidiophores, and in the brown not olivaceous conidia.

It is said to occur on leaves and twigs in New South Wales, but I have not had an opportunity of examining specimens. (Plate I., and Figs. 17, 18.)

## 11. LEMON-SCURF.

(*Cladosporium furfuraceum*, n. sp.)

Forming dingy-white patches on surface of Lemon, ultimately becoming dotted over with brownish-black spots. The discoloured portions readily peel off in minute flakes, and the Lemon becomes scurfy in appearance. Hyphae yellowish-green, septate, branched, regular or irregular, in breadth $4$–$5\frac{1}{2}\mu$.

Conidia ovate to pear-shaped, lemon-yellow, continuous or 1-septate, not constricted at septa, pretty constant in size, 15–17 × $8\frac{1}{2}$–$9\frac{1}{2}\mu$.

On Lemons from Doncaster and elsewhere, Victoria.

There are various species of this scab-causing genus on Oranges and Lemons, but the present one is distinct from the shape, size, and colour of the conidia. The minute flakes readily carry the disease, hence its comparatively wide distribution. (Figs. 19, 20.)

## 12. GREYISH-BROWN SCAB.

(*Cladosporium subfusoideum*, n. sp.)

Greyish-brown scab, overspreading green or yellow lemon, mostly on one side, cracking and becoming covered in patches with dusky layer.

Hyphae ascending, dark olive, septate, very sparingly branched, average $4\mu$. thick.

Conidia produced at apex, similarly coloured to hyphae or paler, 1–3–septate, not constricted at septa, smooth, fusiform, or subfusoid, $12\text{–}15 \times 3\frac{1}{2}\text{–}4\mu$.

A *Macrosporium* form is occasionally associated with this, in which the conidia are dark-coloured, clavate, with transverse and longitudinal septa, $34\text{–}37 \times 13\text{–}15\mu$.

On yellow Lemons, September, 1898, Wandin Yallock, Victoria.

On green Lemons, February, 1899. Parramatta, New South Wales (Cairnes).

The scab not only spoils the appearance of the fruit, but interferes with its proper ripening as well as its keeping qualities. Lemons thus affected soon become a prey to mould, as well as other fungi, such as *Diplodia* and *Sphaeropsis* found on the same scabby fruit. (Plate V and Figs. 21, 22.)

## 13. GREY SCAB OF ORANGE AND LEMON.

(*Sporodesmium griseum*, n. sp.)

Scab consisting of a dirty-grey incrustation, either continuous or scattered, and cracking into irregular areas. Hyphae of at least two kinds.

(*a*) Colourless to pale-green creeping hyphae, septate, segments elongated and cylindrical, slender, about $2\mu$. broad, bearing at their apex—

Conidia same colour as hyphae, elliptical, $5\frac{1}{2}\text{–}6\frac{1}{2} \times 3\frac{1}{2}\text{–}4\mu$.

(*b*) Dark olive-green hyphae, very irregular, and often aggregated in isolated masses, thin-walled and segments elongated, or thick-walled and segments rounded, often muriformly divided.

Conidia of the same colour, and either Cladosporium-like and uni-septate, or 2 to 3—septate and oblong, or obovate, sometimes with longitudinal septa, size up to $21 \times 9\mu$.

On ripe Oranges and Lemons. October–March. New South Wales.

This is a very common scab on the Lemon particularly, greatly disfiguring the fruit and preventing it reaching its full size.

Each flaky portion is permeated and overrun with hyphae, and countless conidia lie on the surface. The fungus seems to approach nearest to Sporodesmium. (Plate V., Figs. 23, 24.)

## 14. BLACK SCURF

(*Coniothecium scabrum*, n. sp.)

At first causing minute depressions on skin, then gradually spreading to form large black patches. Mycelium usually scanty, creeping, and consisting of pale-green septate hyphae, segments being very variable in shape and thickness, then becoming darker green, and ultimately of a greenish-brown tint. Conidia greenish-brown to smoky-brown, cruciately or radiately septate, quadrangular to oblong, but very variable, from 18$\mu$. upwards, and clustered together into irregular masses.

Arising here and there, and probably connected with it, are solitary, upright, greenish to brownish, simple, septate filaments, bearing conidia of the same colour at their apex, suggestive of *Cladosporium* and *Helminthosporium.*

On still green Oranges and Shaddocks. April, 1899. Burnley, near Melbourne.

I have assigned the fungus to the above genus because although other forms are present, this one is undoubtedly the most common. (Plate IV., and Figs. 25, 26, 27, 28, 29, 30.)

## 15. WART-GROWING FUSARIUM.

(*Fusarium epithele*, n. sp.)

Minute pink cushions growing on warts of Lemon.

Hyphae dense, septate, branched, slender, about 2$\mu$. broad.

Conidia produced at the tips, hyaline, curved, acute at both ends, with very distinct apparently projecting septa, 3-septate, 28–30 × 3$\mu$.

On warts of Lemon. August and September, 1898. New South Wales (Meeking).

The conidia are very regular in size, shape, and septation, and contents somewhat granular. It seems a very distinct species. (Fig. 31.)

## 16. ANTHRACNOSE OR BLACK SPOT.

(*Phoma citricarpa*, n. sp.)

Spots dark-brown, at first whitish or greyish towards centre, but may ultimately become of one uniform colour, round, sunken, solitary or confluent, varying in size from 1 mm. to 5 mm., and, when confluent, forming large irregular patches ($\frac{3}{4}$in. or more).

Hyphæ permeating rind, hyaline, septate, branched, 4–5$\frac{1}{2}\mu$. broad.

Perithecia, solitary or in groups, sometimes circularly arranged, minute, black, but dark-brown by transmitted light, punctiform, globular, erumpent; pore about 20$\mu$. diameter, although it may be somewhat elliptical, 100–120$\mu$. diameter. Sporules hyaline, somewhat variable in shape, elliptical to ovate or even pear-shaped, with conspicuously granular contents, 8–11 × 4$\frac{1}{2}$–6$\mu$., average 9$\frac{1}{2}$ × 5$\frac{1}{2}\mu$. (stained a light green by Potassium-iodide-iodine); basidia hyaline, slender, about 6$\mu$. long.

On ripe or still green Oranges, Lemons, and Mandarins, winter, spring, and summer. New South Wales.

The round sunken conspicuous spots are generally of a ruddy-brown tint, and paler in the centre where the pustules are seated.

This is a distinctive species in the small size of the perithecia, as well as in the size and shape of the sporules. (Plate II. and Figs. 32, 33, 34, and 186.)

## 17. WITHER-TIP, ROOT-ROT, OR BLACK SCAB OF FRUIT.

(*Phoma omnivora*, n. sp.)

Perithecia on greyish or dingy black patches, minute, black, gregarious, slightly erumpent, firm, membranaceous, globose to sub-globose, dark brown by transmitted light, with papillate apical pore, 150–160$\mu$. diameter or less.

Sporules hyaline, cylindrical, rounded at both ends, escaping in a mucilaginous tendril, minute 3–3$\frac{1}{2}$ × 1–1$\frac{1}{2}\mu$.

Common on fruit, leaves, stems, and roots of Oranges, Lemons, and Citrons. September, 1898—August, 1899. All the year round. Victoria, New South Wales, South Australia (Quinn), and West Australia (Helms).

This species resembles *P. limonis* (Thuem.) in the size of the sporules, but the perithecia are not patelliform nor immersed, and the habit is entirely different, being found on green twigs and leaves, stems, and roots, as well as on green and ripe fruit.

*Fruit.*—The still green or ripe fruit is conspicuously scabbed, giving it either a dirty grey or dingy black appearance over the whole of one side, and causing little patches to flake off.

*Leaves.*—The leaves may wither at the tip, when nothing remains but shreds of the grey membranaceous epidermis studded with perithecia ; or other portions may have the dirty grey patches and the tissue become disorganized and destroyed.

*Branches and Stems.*—Greyish blotches, usually on one side, at first isolated, then continuous in long lines, destroying and rupturing the tissues so as to expose the wood, and with the uninjured tissue raised around. The terminal portions of the twigs usually die off, and the grey blotches may also appear at the base of the dead twigs, adjoining the still living green tissue.

*Roots.*—The diseased portions are dark brown or almost black, and the pustules may occur either on the bark or where denuded of the outer bark.

Associated, and probably genetically connected, with this species, were several other fungi.

*Pleospora limonum* (Penz.), found on languid leaves of Lemon, seems to represent the highest or ascomycetal stage, and *Sporodesmium griseum* (McAlp), the conidial stage. (Plates VII. and VIII., and Figs. 35, 36, 37, 38, 39, 40.)

## 18. CITRUS SPHÆROPSIS.

(*Sphæropsis citricola*, n. sp.)

Perithecia scattered or somewhat gregarious, minute, black, dark-brown by transmitted light, slightly erumpent, sub-globose, about 130$\mu$. diameter.

Sporules dark-brown in mass, light-brown individually, thick-walled, elliptic, $5\frac{1}{2}$–$7\frac{1}{2}$ × $4$–$4\frac{1}{2}\mu$.

On scab of Lemon and Lemon leaf produced by *Cladosporium subfusoideum* (McAlp). Wandin Yallock, Victoria; Parramatta, New South Wales.

On scab of Lemon leaf. April, 1898. Cooroy, Queensland (Tryon).

On bark from stem of Lemon affected with "Root-rot." February, 1899. Doncaster, near Melbourne.

Associated and intermixed with *Diplodia citricola* (McAlp).

Only a few perithecia were met with on the Lemon scab, the Diplodia being the principal form.

On Lemon leaf from Queensland the perithecia occurred on the lower surface of the midrib, where it was slightly scabbed and discoloured.

On the Lemon stem the sporules were more nearly spherical, being on the average $5\frac{1}{2}$ × $4\frac{1}{2}\mu$. (Figs. 41, 42).

## 19. CITRUS DIPLODIA.

(*Diplodia citricola*, n. sp.)

Perithecia gregarious, minute, punctiform, slightly erumpent, black, golden-brown by transmitted light, sublenticular with distinct papillate pore, 180–200 × 150–170$\mu$.

Sporules at first colourless and continuous, finally brownish in mass, uniseptate, not constricted at septa, elongated elliptic, rounded at both ends, 6–8 × $2\frac{1}{2}$–$3\frac{1}{2}\mu$.

On Lemon scab caused by *Cladosporium subfusoideum* (McAlp). Wandin Yallock, Victoria, September, 1898 ; Parramatta, New South Wales, February, 1899.

On green Lemons. March, 1899. Burnley, near Melbourne.

On Knight's Citron fruit, leaves, and twigs. Burnley, near Melbourne.

On Lemon stem, associated with "Collar-rot." April, 1899. Malvern, near Melbourne.

On Lemon twigs and stem. July, 1899. Doncaster, near Melbourne.

This fungus was found to be more common in wet than in dry situations, and occasionally limbs of a tree were killed by it, according to one grower ; but generally it seemed to be saprophytic and associated with other fungi. (Plate V., Figs. 43, 44.)

## 20. BROWN BLOTCH OF LEMON.

(*Septoria depressa*, n. sp.)

Depressions on skin of Lemon, brownish to blackish, irregularly circular, glistening when fresh, may be either dark towards the centre and ruddy-brown towards the circumference, or the reverse, varying in size from $\frac{1}{4}$-inch to 1 inch in diameter, and several may run together. Perithecia minute, punctiform, immersed, black, in small groups, globular to sub-globose, opening by pore, about 112$\mu$. diameter. Sporules hyaline, sub-cylindrical, straight or slightly curved, usually 1–septate, sometimes slightly constricted at septum, with rounded ends, average 15 × 2$\mu$., but varying in size from 13–19 × $1\frac{1}{2}$–$3\frac{1}{2}\mu$.

Disfiguring the skin of Lemons and Citrons. Doncaster and Burnley, near Melbourne.

It differs from *S. citri* (Pass.) in the larger perithecia and in the sporules, being curved as well as straight, but not fusiform.

It approaches *Ascochyta* in its characters.

This is a disease which occurs on the best lemons, usually attacking them when ripe. It seems to agree with Red Blotch of the Lemon described by Dr. Cobb, in *Ag. Gaz.*, New South Wales, Vol. VI., Pt. 12, p. 864 (1895), but in the absence of details as to perithecia, &c., nothing definite can be stated.

There is a disease of Mandarins, already referred to, caused by a Septoria *S. glaucescens* (Trabut), and known as "Melanose," although causing a greyish-green discoloration. Trabut kindly sent me a specimen of the disease, and it will be seen from the drawing of the sporules (Fig. 47) that they are distinct, being hyaline, straight or curved, cylindrical, and no septa observed, 17–19 × $1\frac{1}{2}\mu$. (Figs. 45, 46, 47.)

## 21. BACTERIOSIS OR SOFT ROT OF LEMONS.

The Lemons were ripe and firm and usually on one side, or it may be on any portion of the fruit, there appeared depressions. These depressions are discoloured, soft, and with a brownish margin, of a circular or irregular shape, and varying in size from half-an-inch in diameter to half the circumference of the Lemon.

At first the colour is rather bleached, then it may become brownish. The surface of the diseased patch is covered with a slimy slightly viscid moisture, containing innumerable bacteria.

On ripe Lemons. September, 1898. Glen Holford, Stawell (Wettenhall).

The softening and discoloration of the skin may extend its entire depth to the juicy interior.

The grower informs me that this disease was first noticed in 1897, and, in reply to queries, that it first appears when the fruit is on the turn in colour, and that it comes out very strongly on stored Lemons and is favoured by moisture. It is not due to chafing on the spurs, because it appears where Lemons have no chance of being bruised in this way, still, no doubt, where such chafing occurs would predispose that part to the disease. The grower also noticed that there are blotches on the young shoots similar to those on the fruit.

Specimens have been submitted to Dr. Cherry of the Bacteriological Laboratory, University of Melbourne, and in due course will be investigated and reported upon.

## II. FUNGI ON LEAVES.

22. Sphærella citricola.
23. Sphærella sicula.
24. Pleospora disrupta.
25. Pleospora herbarum.
26. Pleospora limonum.
27 Ramularia scabiosa.
28. Cladosporium corrugatum.
29. Cladosporium elegans.
30. Cladosporium herbarum.
31. Clasterosporium citri.
32. Heterosporium variabile.

II. Fungi on Leaves—*continued.*

33. Sporodesmium triseptatum.
34. Coniothecium citri.
35. Macrosporium citri.
36. Macrosporium disruptum.
37. Fusarium roseum.
38. Epicoccum granulatum.
39. Phyllosticta hesperidearum.
40. Phyllosticta longispora.
41. Phyllosticta scabiosa.
42. Phoma flaccida.
43. Phoma hesperidum.
44. Phoma rhodospora.
45. Dothiorella federata.
46. Pyrenochæta destructiva.
47. Coniothyrium citricolum.
48. Coniothyrium cervinum.
49. Diplodia destruens.
50. Ascochyta citricola.
51. Hendersonia citri.
52. Hendersonia socia.
53. Septoria flaccescens.
54. Septoria westraliensis.
55. Glœosporium citricolum.
56. Glœosporium tenuisporum.
57. Colletotrichum glœosporioides.
58. Pestalozzia funerea.

## 22. CITRUS SPHÆRELLA.

(*Sphærella citricola*, n. sp.)

Perithecia loosely gregarious, minute, black to fuliginous, immersed, membranaceous, sub-globose, shortly papillate with round pore, about 100$\mu$. diam. and pore 18–20$\mu$. diam.

Asci elongated-clavate to fusoid, shortly stalked, 37–41 × 11–13$\mu$.

Sporidia 8, sub-hyaline, narrowly oblong, rounded at both ends, distichous, very slightly constricted at septum, with finely granular contents, 13–15 × $3\frac{1}{2}$–4$\mu$. On both surfaces of withered tip of Lemon leaf. April, 1898. Corroy, Queensland. (Tryon.)

It differs from *S. gibelliana* (Pass.) in the asci being twice as broad and the sporidia much longer. In the immature stage, the sporidia are continuous and oval, and towards maturity they become elongated and uniseptate.

It was found associated with *Colletotrichum glœosporioides* (Penz.). (Figs. 48, 49.)

## 23. POINTED SPHÆRELLA.

(*Sphærella sicula*, Penz.)

Very minute, densely gregarious, punctiform pustules, standing out like the pile in velvet, on both surfaces of leaf but mostly on underside, on greyish patches, blackish from the numerous points.

Perithecia covered by the raised epidermis, depressedly globose, membranaceous, with circular mouth. (19–20$\mu$. diam.) 90–120$\mu$.

Asci fasciculate, without paraphyses, elongated-fusoid to cylindrical, sub-sessile, somewhat truncate at apex, 8-spored, 37–43 × 5–6$\mu$.

Sporidia distichous, hyaline, fusoid, 1-septate, not constricted at septa, 10–11 × 3–3½$\mu$.

On fallen and decaying leaf of Orange. October, 1897 Gembrook, Victoria.

The perithecia reached a size of 120$\mu$. instead of 90$\mu$., and the asci averaged 40$\mu$. long instead of 26$\mu$., but otherwise there was agreement with the above species.

It was found closely associated with *Pleospora herbarum* (Rab.) and the epidermis around it had sometimes a puce tint. (Figs. 54, 55.)

## 24. DESTROYING PLEOSPORA.

(*Pleospora disrupta*, n sp).

Perithecia scattered or somewhat gregarious on irregularly-shaped dingy ashen-grey blotches, either small or becoming large patches (1 inch or more) and destroying tissue of leaf. Minute, black, immersed, spherical, with relatively large mouth, average 150$\mu$. diam.

Asci oblong-clavate, rounded at apex and abruptly tapering at base, 8-spored, without paraphyses, 60–75 × 24–34$\mu$.

Sporidia, 2 to 3 rowed, bright yellowish-green, elongated ellipsoid, 5-septate, constricted at septa, with longitudinal divisions 37–40 × 13–15$\mu$.

On green leaves of Orange. March, 1899. Burnley, near Melbourne.

The tissue of the leaf is completely disorganized by the fungus and ultimately it is reduced to the upper epidermis of the diseased patch, which finally falls away. The specific name is given from the way in which portions of the leaf affected are broken up and destroyed.

This species differs from *P. hesperidearum* (Catt.) occurring on Citrus fruits, in the asci being only about half the length and the narrower sporidia. There is a conidial form associated with this which I have named *Macrosporium disruptum*. (Figs. 50, 51, 52.)

## 25. COMMON PLEOSPORA.

(*Pleospora herbarum*, Rab.)

On languid leaves of Lisbon Lemon. Lancaster, Victoria. Orange leaves, Armadale, near Melbourne. Lemon twig. July, 1899. Hawthorn, near Melbourne. (Fig. 53.)

## 26. LEMON PLEOSPORA.

(*Pleospora limonum*, Penz.)

Scattered or loosely gregarious, minute, black, immersed, then erumpent pustules on brown-coloured portion of leaf surrounding tissue destroyed by *P. omnivora.* Perithecia depressed globose, dark-brown to golden-brown by transmitted light, coriaceous, of parenchymatous texture, fibrillose at base, up to 300$\mu$. diam. with round to elliptical slightly papillate mouth (47$\mu$. diam. or 65 $\times$ 40$\mu$.).

Asci oblong-clavate, sometimes somewhat cylindrical, rounded at apex and shortly stalked at base, 94–120 $\times$ 20–22$\mu$. Paraphyses hyaline, filiform, simple, tapering slightly at apex, equal in length or slightly longer than ascus, up to 10–septate, $2\frac{1}{2}$–3$\mu$. broad. Sporidia bright-greenish yellow, generally two-rowed, elongated oblong, five transverse septa, and three thicker than the others, not constricted at septa, except median, one also longitudinally divided, 24–30 $\times$ 11–13$\mu$.

On languid leaves of Lemon. August, 1899. Burnley, near Melbourne.

This species has been found in Italy on the leaves of the Lemon, but rarely, and this may be owing to the fact that it appears only to occur at certain seasons of the year.

I consider this to be the highest or Ascomycetal stage of *Phoma omnivora* from the mode of its occurrence.

*P. omnivora* was found on the grey patch of the leaf where the substance is reduced by it to the epidermis, and that soon falls away. On the brown tissue immediately surrounding this, *P. limonum* occurred. On the 1st of May, some of the leaves of this Lemon tree were carefully examined, and only immature perithecia with asci were found, but on examining leaves from the same tree on the 4th of August, plenty of perithecia with mature asci were found. It would appear that after the *Phoma omnivora* has destroyed the tissue within a given area and weakened the leaf so that it soon falls, it produces its higher stage towards the winter (August), so that when the leaf falls to the ground, the spores may rest until a favorable opportunity for germination occurs. This may account for the occurrence of the fungus on the roots as well as on other parts of the tree, for the spores could readily be carried into the soil by the rain, &c., and there attack the fresh tips of the feeding roots.

Penzig first described this in 1882 as *P. media* (Niessl), which also occurs on dead and dry stems of various species of plants. Then Saccardo, in 1883, constituted it a variety *Limonum*, principally from its occurring on languid leaves and not on dead portions of the Lemon. Its occurrence, however, is so different from that of *P media*, and its connexion with *P. omnivora* is so marked, that it seems to me worthy of specific rank, accordingly it is named *P. limonum* (Penz.). (Figs. 115, 116, 117, 118, 119, 120.)

## 27. SCABBING RAMULARIA.

(*Ramularia scabiosa*, McAlp. and Tryon.)

Spots well defined, light-brown, circular, with waved margin, about 2mm. diam., border slightly raised, and in old specimens ultimately black; central area depressed, darker in colour than the rest; finally raised with the whole spot, which becomes uniformly brown, much above surface of leaf.

Fertile hyphæ tufted, free, erect, simple, sometimes continuous, but usually obscurely septate, even, or constricted here and there, for the most part straight, pale-coloured to hyaline, containing granules, and longer than conidia.

Conidia similarly coloured, terminal, single, or sometimes two in succession, cylindrical, ends obtuse, 8–9 × 2$\mu$., 1-septate, each division guttulate and containing granules.

On both surfaces of living leaves and on petioles of Oranges and Lemons. Common at Toowoomba and South Queensland (Tryon).

This species is fully described by H. Tryon in his "Report on Insect and Fungus Pests," pp, 144, 145, Queensland, 1889.

*R. citri* (Penz.). is entirely different from this species in producing no spot, in the conidia being rarely 1-septate, and 8–14 × $3\frac{1}{2}$–4$\mu$., and in occurring only on dry and fallen leaves (of Orange). (Fig. 56.)

## 28. CORRUGATING CLADOSPORIUM.

(*Cladosporium corrugatum*, n. sp.)

Forming densely crowded, confluent, black olivaceous tufts on both surfaces of leaf, on oval or large irregular dark-grey patches, with ruddy-brown margin on upper surface, and of a yellowish-brown on under surface.

Hyphæ olive-green, septate, sparingly branched, often curved, radiating, $5\frac{1}{2}\mu$. broad.

Conidia terminal and lateral, may be at least in chains of two, at first ovate to elliptical, colourless or pale-green with finely granular contents, finally olive green, smooth, elliptic-oblong, 1–3-septate, not constricted at septa, 9–15 × $4\frac{1}{2}$–$5\frac{1}{2}\mu$.

On both surfaces of green Orange leaves. January, 1899. Armadale, near Melbourne.

The patches generally extend from the margin of the leaf to near the midrib, and are of irregular shape. The surface of the patch is usually more or less corrugated, and the tissue of the leaf is so destroyed that the epidermis is easily lifted with the tufts.

It differs from *C. compactum* (Sacc.) in being on both surfaces of leaf, and the hyphæ are branched and septate. (Fig. 57.)

## 29. ELEGANT CLADOSPORIUM.

(*Cladosporium elegans*, Penz.)

Spots fawn-coloured, subrotund to oval, slightly depressed, and ruddy-brown towards margin, penetrating entire tissue of leaf, varying in size from $\frac{1}{8}$th to 1 inch or more ; tufts minute, rounded, gregarious, dark olivaceous.

Hyphæ radiating, rigid, pale-green or dark olive, sinuous, simple, sparingly septate, 75–85 × 4–$5\mu$.

Conidia terminal and lateral, pale-green to almost colourless, generally uni-septate, sometimes continuous, or 2 to 3 septate, elongated elliptic, epispore finely granular, variable in size, 14–19 × 4–$5\mu$.

On upper and under surface of green Orange leaves.

October, 1898. Armadale, near Melbourne.

The fungus produces a spot right through the tissue of the leaf and the tufts appear first on the upper surface, then on the under surface. The lateral conidia are produced earlier than the terminal conidia, and have fallen away while the latter are still young and colourless. (Figs. 58, 59.)

## 30. COMMON CLADOSPORIUM.

(*Cladosporium herbarum*, Link.)

On withered tip of Orange leaf. Armadale, near Melbourne.

## 31. CITRUS CLASTEROSPORIUM.

(*Clasterosporium citri*, n. sp.)

Mixed with tufts of *Cladosporium herbarum* on grey patches on Lemon leaf.

Hyphæ creeping, septate, slightly branched, pale-brown, average $3\frac{1}{2}$–$4\mu$. broad.

Conidia yellowish-brown, fusoid, grub-like, hardly constricted, 8–septate, 45 × 8$\mu$.

On languid Lemon leaves. August, 1899. Burnley, near Melbourne.

The leaves were badly affected with *Pleospora limonum* (Penz.), and this was probably a stage in the development of that fungus. (Figs. 123, 124.)

## 32. VARIABLE HETEROSPORIUM.

(*Heterosporium variable*, Cooke.)

Tufts minute, distinct, compact.

Hyphæ fasciculate, bright olive-green, radiating, rigid, simple, septate, only slightly constricted at septa, average 84 × 5$\mu$., originating from slender green filaments inside leaf, only 2$\mu$. broad.

Conidia paler in colour, produced at apex, finely echinulate, cylindrical, 1–4 septate, not constricted at septa, 20–30 × $5\frac{1}{2}$–$7\frac{1}{2}\mu$.

On leaf of Knight's Citron. April, 1899. Burnley, near Melbourne.

The hyphæ are bright olivaceous and the conidia are distinctly echinulate.

It agrees generally with Cooke's species, but the hyphæ are of a strikingly bright olive, and not dusky olive, and the conidia are rather narrower. (Figs. 60, 61.)

## 33. TRI-SEPTATE SPORODESMIUM.

(*Sporodesmium triseptatum*, n. sp.)

Mycelium forming a pavement of cells, more or less continuous, over surface of scab.

Hyphæ colourless to pale greenish or yellowish-green, septate, close-jointed, moniliform, or segments polygonal or elongated, creeping, with short projecting hpyhæ here and there.

Conidia various :—

(*a*) Colourless to very pale-green, in chains, continuous, somewhat fusiform or elongated oval, 9–11 × 3–4$\mu$. (Ovularia-form.)

(*b*) Pale yellowish-green to brown, in chains (at least of two), thick-walled, 1–2–septate, constricted at septa, smooth, 9–15 × 5–7$\mu$. (Cladosporium form).

(*c*) Pale-brown, oblong, 3–septate, constricted at septa, with one or two longitudinal septa, smooth, 23–26 × 13–15$\mu$.

On Lemon-leaf. April, 1898. Cooroy, Queensland (Tryon).

The three forms of conidia were found associated with *Colletotrichum glœosporioides* on the pale brown withered portion of leaf, but on the scabby portion only (*a*) and (*b*) were met with.

This fungus, which is probably only the conidial phase of some higher form, occurs generally on the surface of the scab as a streaky discolouration, and consists of a more or less continuous layer of colourless or yellowish-green hyphæ bearing similarly coloured conidia of the *Monilia* and *Cladosporium*-type. On the withered tip of the leaf, free from the scabs, there was found in addition a *Sporodesmium*-type of conidium, associated with the *Colletotrichum* and *Sphaerella*.

While the primary cause of the scab-like bodies may have been the Scarlet Mite observed by Mr. Tryon, they were afterwards invaded by this fungus, which also caused the decay towards the tip. (Figs. 62, 63, 64, 65.)

## 34. CITRUS CONIOTHECIUM.

(*Coniothecium citri*, n. sp.)

Forming numerous, minute, brownish patches, with raised brown or black margins, on upper surface of leaf, often confluent and ultimately producing irregular ruptures.

Tufts very small, black, often effused.

Hyphæ very scanty, short, creeping, up to 7$\mu$. broad.

Conidia smoky yellowish-brown, semi-pellucid, in irregular clusters, cruciately divided, somewhat oblong, average, 19–20$\mu$.

On Orange-leaf. March, 1899. Wangaratta, Victoria.

This species is quite different in habit from that found on the fruit of the Shaddock. *C. scabrum* (McAlp.) forms black effused patches resembling "Sooty Mould," while this one occurs on definite spots circumscribed by regular raised margins. It is undoubtedly the cause of the rupturing and ultimate decay of the leaf, so that although this genus is badly defined and many of the species are doubtful, still it produces definite effects, and, from the point of view of Vegetable Pathology, is quite as distinct as any other species. (Figs. 66, 67.)

## 35. CITRUS MACROSPORIUM.

(*Macrosporium citri*, n. sp.)

Forming densely gregarious, numerous, minute, dingy-green tufts, particularly along veins and covering otherwise diseased spots, mostly on under surface of leaves.

Hyphæ fasciculate, ascending, septate, not constricted at septa, occasionally sparingly branched, olivaceous or pale green, 5–7½$\mu$. broad and sometimes 137$\mu$. long. Conidia variable in form and size, pear-shaped, oblong, obovate, or clavate, tapering towards base or distinctly stalked (15μ. long), a-septate to 6-septate, constricted at septa, longitudinal and oblique septa as well as transverse, pale or dark olivaceous up to 60 × 20½μ., and average breadth from 15–20½μ.

On leaves of Lemon. June. South Australia (Molineux).

*M. commune* (Rabh.) and *M. rosarium* (Penz.) are both recorded on Lemon leaves, but this form differs from the former in the tufts and hyphæ not being brown but greenish, in the generally larger conidia, and in the absence of a minutely granular epispore. It differs from the latter also in the tufts and hyphæ not being brown, in the joints of hyphæ not being inflated or pear shaped, in the much longer but more slender conidia, and in the absence of a granular to echinulate epispore. The conidia are not superimposed as in Alternaria. (Figs. 68, 69.)

## 36. DESTROYING MACROSPORIUM.

(*Macrosporium disruptum*, n. sp.)

Hyphæ tufted, yellowish-green to brownish, thick-walled, simple, sparingly septate, slightly sinuate, average 112 × 9μ.

*Cladosporium-stage.*—Conidia yellowish-green, apical, small and large. Small elliptical, 1–septate, average 10 × 5½μ.; large oval to oblong, 1–3–septate, finely echinulate, 20–30 × 11–15μ.

*Macrosporium-stage.*—Conidia yellowish green, clavate, up to 7–septate, muriformly divided and constricted at septa, shortly stalked, reaching 47 × 15μ.

On green leaves of Orange. March, 1899. Burnley, near Melbourne.

This form is associated with *Pleospora disrupta* (McAlp.), and largely assists in destroying the tissue. (Figs. 70, 71, 72.)

## 37. ROSY FUSARIUM.

(*Fusarium roseum*, Link.)

Sporodochia minute, sessile, sub-globose or rather effused, and then bursting through epidermis like a rust-pustule, gregarious, pale orange, or coral pink.

Hyphæ pinkish in the mass, fasciculate, septate, dichotomously branched towards apex, 3–4μ. broad.

Conidia produced at the tips of the branches, fusiform, straight or slightly curved, acute at both ends or blunt at attached end, typically 3–septate, may be 1–4–septate, with granular contents, average 34–45 × 3½–4½μ.

On withered portion of Lemon-leaf. May, 1899. Burnley, near Melbourne. Closely associated with *Diplodia destruens* (McAlp.), also *Hendersonia socia* (McAlp.).

On languishing or dead twigs of Orange. September, 1898 to July, 1899. Armadale, near Melbourne. Rare in spring (September), but more plentiful in winter (July).

The minute rust-like burst pustules were seated on the bark of the Orange-tree at the base of a dying twig, and adjoining fresh green wood. The cortex was still green beneath the ruptured pidermis, and various other fungi were associated with it, such as *Phoma omnivora* (McAlp.). (Fig. 73.)

## 38. GRANULAR EPICOCCUM.

(*Epicoccum granulatum*, Penz.)

Sporodochia minute, hemispherical, jet black, gregarious, may be confluent, pulverulent, just visible to naked eye.

Stroma hemispherical, rich ruddy brown.

Conidia olivaceous, with brownish tinge, sphaeroidal, not pedicillate, many-celled and meshes of network slightly raised on surface, punctate-granular 20–28$\mu$. diameter.

On decayed portions of fading Lisbon Lemon leaves. May, 1899. Burnley, near Melbourne. (Figs. 105, 106, 107.)

## 39. CITRUS PHYLLOSTICTA.

(*Phyllosticta hesperidearum*, Penz.)

On dirty-grey or brown, irregular, often confluent, slightly raised patches on upper surface of leaf, and the same or ruddy-brown blister-like patches on under surface.

Perithecia gregarious, slightly erumpent, punctiform, black, but golden-brown by transmitted light, with relatively large mouth, depressed globose, of parenchymatous texture, membranaceous, 100–180$\mu$. diameter.

Sporules hyaline, cylindrical to elliptic, rounded at both ends, $3\frac{1}{2}$–$5\frac{1}{2} \times 2$–$2\frac{1}{2}\mu$.

On living Lemon leaf. February, 1899. Doncaster, near Melbourne.

On living Orange leaf. June, 1899. Armadale, near Melbourne.

*Pleospora herbarum* (Rab.) appeared on the disrupted tissue in one case, and the leaf was affected with Sooty Mould in another.

Larger or smaller patches occur on the leaf, sometimes at the margin and sometimes adjoining midrib. The fungus gradually breaks down the tissue until nothing is left but the veins, and these finally drop out leaving a large hole, or the margin is worn away. (Figs. 74, 75, 76.)

## 40. LARGE-SPORED PHYLLOSTICTA.

(*Phyllosticta longispora*, n.sp.)

Tip of green leaf withered for fully half-an-inch, and spot at lower margin, greyish, elliptical, about $\frac{1}{8}$-inch with margin raised, and brownish on upper surface, but less distinct on under surface.

Perithecia scattered, immersed, dark-brown, globular, $170\mu$. in diameter, darker and thicker surrounding mouth which is about $40\mu$. diameter.

Sporules hyaline, elongated-elliptic, with finely granular contents, average $10–13 \times 4–4\frac{1}{2}\mu$.

On green leaves of Orange. December, 1898. Armadale, near Melbourne.

The tissue of the leaf is destroyed, leaving only the membrane of the upper epidermis which finally disappears leaving a hole. Not common. The size of the spore distinguishes it at once from other Citrus species of Phyllosticta. (Figs. 77, 78.)

## 41. SCAB-PRODUCING PHYLLOSTICTA.

(*Phyllosticta scabiosa*, n. sp.)

Minute, black, punctiform, slightly erumpent pustules on scabs on Lemon leaf.

Perithecia scattered, membranaceous, delicate, flattened sub-globose, with minute apical pore, about $90 \times 80\mu$.

Sporules hyaline, elliptical, $5\frac{1}{2}–6\frac{1}{2} \times 2\mu$.

On "scabs" on Lemon leaf. January. Palmwood, Queensland (Tryon).

On similar scabs, *Ramularia scabiosa* was found, which is very probably only a conidial stage of this fungus.

This species approaches *P. disciformis* (Penz.), but the sporules are narrower and hardly elliptical, and the "scabby" spots do not occur with the latter.

It probably occurs wherever *R. scabiosa* is found, although I have only had an opportunity of examining it on a Lemon leaf. (Figs. 79, 80.)

## 42. WITHERING PHOMA.

(*Phoma flaccida*, n. sp.)

Minute, black, gregarious, immersed, punctiform pustules on withered tip of Orange leaf, most numerous on upper surface.

Perithecia dark-brown, depressed globose, $170\mu$. diameter, with elliptical papillate mouth, $45 \times 32\mu$.

Sporules greenish in mass, hyaline individually, continuous, elliptical or ovoid, 1-guttulate, $3\frac{1}{2}$–$4\frac{1}{2}$ × $2\frac{1}{2}$–$3\mu$., average 4 × $3\mu$.; basidia hyaline, slender, filamentous, 5–$5\frac{1}{2}\mu$. long.

On leaves of Orange. December, 1898. Armadale, near Melbourne.

This is probably the cause of the withering of the tip which may extend considerably down the leaf, which ultimately readily falls. The withered portion is depressed beneath the green portion, so that the line of demarcation seems raised.

It differs from *P. omnivora* (McAlp.) in the ovoid, 1-guttulate, sporules, which are altogether stouter. (Figs. 81, 82.)

## 43. ORANGE AND LEMON PHOMA.

(*Phoma hesperidum*, n. sp.)

Perithecia loosely gregarious, depressed globose or shortly elliptical in outline, slightly erumpent, black, dark yellowish-brown by transmitted light, membranaceous, of parenchymatous texture, with distinctly papillate mouth, average 150 × $130\mu$.

Sporules hyaline, elliptical, $4\frac{1}{2}$–$5\frac{1}{2}$ × $2\frac{1}{2}\mu$.

On Orange and Lemon leaves, and stem of Lemon affected with Collar-rot. April, 1899. Malvern, near Melbourne. It differs from *P omnivora* in the slightly larger spores and flattened perithecia, and from *P. flaccida* in the smaller erumpent perithecia with different mouth. (Figs. 121, 122.)

## 44. PINK-SPORED PHOMA.

(*Phoma rhodospora*, n. sp.)

Minute, black, punctiform pustules on greyish-brown, irregular, slightly raised, often confluent scab-like patches on upper surface of leaf, and ruddy-brown blister-like patches on under surface.

Perithecia sub-globose, depressed gregarious, slightly erumpent, dark brown to golden brown by transmitted light, of parenchymatous texture, with minute knob-like projections, round mouth, about 160–$170\mu$. diam.

Sporules decidedly pinkish collectively, hyaline individually, minute, almost cylindrical, average 4 × $1\frac{1}{2}\mu$.

On lemon leaf also affected with Sooty Mould. February, 1899. Doncaster, near Melbourne.

It is not always easy to distinguish between Phoma with hyaline spores and Coniothyrium and Sphaeropsis with fuliginous spores, on account of the gradations of colour which may occur. Thus the typical hyaline or sub-hyaline spores of Phoma may be hyaline and collectively green (*P. incompta*, Sacc. and Mart.) or entirely green (*P. viridispora*, Cooke), or hyaline to very pale olivaceous (*P. bresadolae*, Sacc.), or pale yellow to hyaline (*P. sphaerosperma*, Karst.), or even pale fuliginous (*P. syringica*, Thuem.). *P. sanguinolenta*, Rostr. is so named on account of the blood-red spores, but there is no record of a Phoma with pink spores, and so I have named it as above. This just shows that, at the best, the colour of the spores is an artificial distinction, and must be treated as a matter of convenience. (Figs. 108, 109.)

## 45. FEDERATION DOTHIORELLA.

(*Dothiorella federata*, n. sp.)

Perithecia in minute erumpent clusters ($\frac{1}{3}$–$\frac{1}{2}$ mm. long) on upper surface of leaf, globose, brown by transmitted light, of parenchymatous texture, with round or oval mouth, average 130$\mu$. diam.

Sporules hyaline, minute, almost cylindrical, rounded at both ends, $3\frac{1}{2}$–$4\frac{1}{2}$ $\times$ $1\frac{1}{2}$–2$\mu$.

On Lemon leaf also affected with "Sooty Mould." February, 1899. Doncaster, near Melbourne.

Only a few erumpent clusters were seen at one spot, the raised epidermis surrounding them like a wall. It differs from *D. placenta* (Sacc.) found on the bark of the Orange, in which the sporules are 15$\mu$. long, and from *D. guaranitica* (Speg.), found similarly, and in which the sporules are 24–26$\mu$. long.

This species was named on 27th July, 1899—Federation day in Victoria. (Figs. 110, 111, 112.)

## 46. DESTRUCTIVE PYRENOCHAETA.

(*Pyrenochaeta destructiva*, n. sp.)

Numerous distinct black pustules on orbicular to oval, grey patches, with ruddy brown margin.

Perithecia on upper or under surface, mostly on upper, at first covered, then slightly erumpent, flattened globose or subglobose, dark-brown by transmitted light, membranaceous, brittle, with scattered spines, particularly round margin, opening by pore, 240–300$\mu$. diam.; spines rigid, brown, tapering towards apex, often curved, 2–3-septate, 70–100 $\times$ $3\frac{1}{2}$–4$\mu$.

Sporules hyaline, cylindrical, continuous, rounded at both ends, bi-guttulate, 17–18 $\times$ 4–5$\mu$. (Stained pale-yellow by Potassium-iodide-iodine).

On leaf of Bitter Orange. July, 1896. Kew, near Melbourne.

On leaf of Shaddock. September, 1892. University gardens, Melbourne.

The green portion of the leaf affected is entirely used up, leaving the fibro-vascular bundles intact, covered by the upper and under grey membranaceous epidermis.

Closely associated with the perithecia was a species of *Cladosporium*, with short, pale-green, almost colourless, scanty hyphæ, 2$\mu$., broad and apical conidia, similarly coloured, or olivaceous, smooth, elliptical, 1-septate, constricted usually at septa, 11–16 × 5–8$\mu$. (Figs. 83, 84, 85, 86.)

## 47. CITRUS CONIOTHYRIUM.

*Coniothyrium citricolum*, n. sp.

Minute, black, punctiform pustules on greyish white, dry spot of leaf, surrounded by raised ruddy-brown margin. Perithecia loosely gregarious, immersed, dark-brown by transmitted light, depressed globose, slightly papillate, 150–200$\mu$. diam.

Sporules very numerous, brown collectively, yellowish-brown individually, shortly elliptical to oval, $4\frac{1}{2}$–$5\frac{1}{2}$ × $2\frac{1}{2}$–3$\mu$.

On living Orange leaves. February, 1899. Doncaster, near Melbourne. It approaches *C. fuckelii* (Sacc.) in the size of the sporules, but they are not olivaceous, and the habit is entirely different.

There is a variety in Europe—*citri* (Penz.), in which the sporules are $2\frac{1}{2}$–3 × $1\frac{1}{2}$–$2\frac{1}{2}\mu$. (Figs. 87, 88.)

## 48. FAWN-COLOURED CONIOTHYRIUM.

(*Coniothyrium cervinum*, n. sp.)

Minute, black, punctiform, scattered pustules on irregular grey to fawn-coloured blotches, without definite margin, on still green leaf, commencing on upper surface, and ultimately penetrating entire tissue.

Perithecia immersed, depressed globose, golden-brown by transmitted light, membranaceous, slightly papillate, round pore surrounded by black thick border, up to 220$\mu$. diam.

Sporules yellowish-brown, elliptical, $5\frac{1}{2}$–$6\frac{1}{2}$ × 3–$3\frac{1}{2}\mu$.

On Lisbon Lemon leaf. May, 1899. Burnley, near Melbourne.

The irregular greyish to fawn-coloured blotches on upper surface of leaf are very characteristic, and when it has completely penetrated the tissue, a few perithecia may occur on the under surface. The sporules are slightly larger than those of *Coniothyrium citricolum*. (Figs. 113, 114.)

## 49. DESTROYING DIPLODIA.

(*Diplodia destruens*, n. sp.)

Minute, black, punctiform pustules, on scabby portions of leaves, or on dirty-grey patches, with ruddy-brown margin, at first running in irregular lines, ultimately expanding, and decayed tissue falling out.

Perithecia somewhat gregarious, immersed, dark-brown by transmitted light, depressed globose or elliptical, with minute apical pore, 150–170$\mu$. diam.

Sporules yellowish-brown to smoky-brown in mass, pale and transparent individually, elliptical, 1-septate, not constricted at septa, straight, average 10 × 4$\mu$.

On Orange leaves. September, 1892. Burnley, near Melbourne. June, 1895. Mount Remarkable, South Australia (Molineux). On Lisbon Lemon leaves. May, 1899. Burnley, near Melbourne. It approaches *D. citricola* found on Lemon scab, but the sporules are longer and broader.

Mr. Molineux in sending the specimens remarks that many trees are similarly affected in the same locality. The leaves have yellowish-brown scab-like patches on their upper surface, often become withered and torn up, and have a general sickly appearance. In the Burnley specimens the tissue affected became grey, and fell out, and the leaves were much paler in colour than the normal.

In young perithecia the sporules are all continuous and olivaceous, and might be readily mistaken for *Coniothyrium olivaceum* (Bon.), var. *hesperidum* (Penz.). (Figs. 89, 90.)

## 50. CITRUS ASCOCHYTA.

(*Ascochyta citricola*, n. sp.)

Perithecia seated on dark-coloured patches of bark, which run in lines and coalesce, and on irregular pale-brown patches on leaves which ultimately decay and fall away.

Perithecia yellowish-brown, punctiform, scattered or somewhat gregarious, globose, membranaceous, about 80–140$\mu$. diam., with conspicuous papillate mouth, averaging 20$\mu$. diam. Sporules hyaline, or a pale transparent greenish tint, uniseptate, narrowly elliptic, rounded at both ends, not constricted at septum, 9–11 × 3–4$\frac{1}{2}\mu$.; average, 10 × 3$\frac{1}{2}\mu$.

On twigs of Lisbon Lemon. September, 1898. South Australia (Quinn).

On withered tip and marginal portions of Orange leaf. January–July, 1899. Armadale, near Melbourne.

On ashy-grey blister-like patches on Lemon leaf. August, 1899. Burnley, near Melbourne.

It differs from *A. cinerea* in the smaller size of the perithecia which are scattered and seated on dark-coloured patches. Also from *A. bombycina* (Penz. and Sacc.), with which the sporules generally agree in size, in their not being constricted at the septum, and the spots not being yellow.

Occasionally a 2-septate sporule may be seen as drawn ($16 \times 4\frac{1}{2}\ \mu$.).

Associated with this fungus were dark-coloured patches, consisting of olivaceous, sometimes almost colourless, septate, branched, hyphæ, often constricted at the septa, ramifying in the bark and spreading on the surface like a felt, and producing—

1. Similarly coloured uniseptate conidia at the apex of the hyphae (*Cladosporium*) or occasionally—
2. Elongated clavate conidia, transversely and longitudinally septate (*Macrosporium*) but mostly—
3. Dense aggregates of dark-olive cells (*Coniothecium*). Sometimes the dark mouldy stage was the most conspicuous feature.

Two specimens obtained quite independently, one on twigs of Lisbon Lemon, from South Australia, and one on Orange leaf from Armadale, near Melbourne, with the same association of moulds, show that there is very probably some intimate connexion between them. (Figs. 91, 92.)

## 51. CITRUS HENDERSONIA.

(*Hendersonia citri*, n. sp.)

Very minute, black, gregarious, punctiform pustules on orbicular greyish spots, with distinct ruddy-brown margin. Perithecia golden-brown by transmitted light, depressed globose, immersed then slightly erumpent, membranaceous, with apical pore, $150–190\mu$. diam.

Sporules smoky-brown, 3-septate, not constricted at septa, elongated elliptic, very distinctly bi- and tri-guttulate, $9\frac{1}{2}–11 \times 3\frac{1}{2}–4\mu$., average $10 \times 3\frac{1}{2}\mu$.

On leaf of Bitter Orange. July, 1896. Kew, near Melbourne.

The median septum is always the darkest and most distinct, as it is the first division of the sporules, and large numbers in the same perithecia are still at that stage. Then a faint septum appears in the upper and lower half, and the mature tri-septate spore is formed. The guttules are very pronounced, especially in the younger uni-septate stages.

This was found on the same leaf as *Pyrenochæta destructiva*, but at a different spot, and completely destroyed the tissue there. This is the first record of the genus on the Citrus family. (Figs. 93, 94.)

## 52. SOCIAL HENDERSONIA.

(*Hendersonia socia*, n. sp.)

Numerous minute, black, scattered punctiform pustules on withered margin of leaf or on bark still green.

Perithecia immersed, sub-carbonaceous, depressed-globose, dark-brown by transmitted light, with apical pore, 170–220$\mu$. diam.

Sporules smoky-brown, 3-septate, often slightly constricted at septa, ellipsoid to oblong, 14–17 × 5–9$\mu$., average, 15 × 5½$\mu$.; basidia hyaline, short, 2–3½$\mu$. broad. On Lemon leaf. May, 1899. Burnley, near Melbourne. On bark of Lemon towards base. July, 1899. Doncaster, near Melbourne.

It differs from *H. citri* (McAlp.) in not being situated on distinct spots of the leaf, and in the sporules being slightly constricted, longer and broader. This species seems to be essentially social in its nature. On the leaf it was associated with *Diplodia destruens* (McAlp.), *Fusarium roseum* (Link), and *Coniothyrium cervinum* (McAlp.). It was found on the Lemon stem, associated with "root rot" and various other fungi, at Doncaster, and at Ardmona it occurred on the bark splitting from the trunk at the collar of a dying Lemon tree, associated with *Phoma omnivora* and *Ascochyta limoni*. (Figs. 95, 96.)

## 53. WITHERING SEPTORIA.

(*Septoria flaccescens*, n. sp.)

Numerous minute, black, punctiform, semi-immersed, crowded pustules on upper surface of brown and withered tips of Orange leaves, adjoining green tissue.

Hyphae yellowish-green, septate, branched, 3½$\mu$. broad.

Perithecia, amber-coloured with greenish tint, depressed globular to lenticular, with circular pore, 120–150$\mu$. or even 200$\mu$. diam.

Sporules hyaline, cylindrical, straight or slightly curved, rounded at both ends, very occasionally uniseptate, vacuolated protoplasm, variable in length, average, 11–15 × 3–3½$\mu$.

On upper surface of Orange leaves, causing withering at the tips. October, 1898. Near Melbourne.

It differs from *S. citri* (Pass.) in the larger perithecia not being situated on disc-like spots, and in the stouter sporules. (Figs. 97, 98.)

## 54. WEST AUSTRALIAN SEPTORIA.

(*Septoria Westraliensis*, n. sp.)

Round to irregularly-shaped spots, distinctly circumscribed by brown margin on under surface of leaf, ashy-grey in colour, and consisting mainly of the colourless membranaceous epidermis which ultimately ruptures and leaves a hole; scarce, minute black pustules on upper surface.

Perithecia innate, ultimately slightly erumpent through colourless epidermis, dark-brown with greenish tint, rough surface and irregularly round, flattened, membranaceous, $170\mu$. diam. with round central pore $15\mu$. diam.

Sporules hyaline, straight or very slightly curved, rod-like, rounded at both ends, but may slightly taper towards one end, distinctly and regularly 3-septate, not constricted at septa, very constant in size $21\frac{1}{2}$–$22\frac{1}{2} \times 3\frac{1}{2}$–$4\mu$.

On still green Orange leaves, also attacked by *Phoma omnivora*. Nov., 1898. West Australia.

Accompanying the perithecia and even overrunning them are numerous, scattered, usually moniliform hyphæ and detached apparently reproductive bodies 2- or 4-celled. (Figs. 99, 100.)

## 55. CITRUS GLŒOSPORIUM.

(*Glœosporium citricolum*, Cooke and Mass.)

Spots dark-brown, small, rather discoid, often confluent.

Pustules immersed.

Conidia oval, continuous, hyaline, $8 \times 6\mu$.

On Orange leaves. Queensland (Bailey).

## 56. SLENDER-SPORED GLŒOSPORIUM.

(*Glœosporium tenuisporum*, n. sp.)

Pustules gregarious, minute, punctiform, greyish-black, slightly erumpent on both surfaces, but mostly on under surface of brown withered portion of leaf.

Conidia hyaline, elongated, slender, bluntly pointed at one or both ends, $13$–$15 \times 1\frac{1}{2}\mu$.

On brown withered portion of Orange leaf. November, 1898. Armadale, near Melbourne.

It differs from species already recorded in the slender character of the conidia. (Fig. 101.)

## 57. GLŒOSPORIUM-LIKE COLLETOTRICHUM.

(*Colletotrichum glœosporioides*, Penz.)

Pustules erumpent, gregarious, often confluent, black to dark-brown, rather discoid.

Bristles cylindrical, surrounding margin or on disc, rounded at apex, sometimes tapering, sparingly septate, dark-brown, $40\mu$. or longer $\times$ $4\mu$.

Basidia fasciculate, cylindrical, apex rounded, dilute fuliginous at base, $18 \times 4\mu$.

Conidia apical, cylindrical, straight, rounded at both ends, hyaline, $13–18 \times 4–6\mu$.

On apparently dead twigs of Orange. September, 1892. Burnley, near Melbourne.

On leaf of Lemon. April, 1898. Cooroy, Queensland (Tryon).

This agrees well with the Italian species, only the bristles in the latter are $40–90 \times 5–6\mu$. It is found there very common on both surfaces of leaf, but rarely on languid branches.

The pustules originate beneath the surface and burst the epidermis very irregularly. It may often be recognised by the naked eye from the concentric arrangement of the pustules, or by the singular depressed form and brown colour of the same. (Figs. 102, 103.)

## 58. BLACK PESTALOZZIA.

(*Pestalozzia funerea*, Desm.)

Pustules scattered, punctiform, black, at first covered, then erumpent; stroma depressed, hyaline; basidia short, simple, continuous, hyaline, $20–24 \times 2\frac{1}{2}–3\mu$.

Conidia oblong-fusiod, 5-celled, slightly or not at all constricted at septa, three central cells very dark-brown, two terminal cells hyaline, $21–24 \times 6–9\mu$., crested with 2–5 spreading, recurved hyaline setae, $10–22 \times 1\mu$.

On scabs on leaves of Lemon. April, 1898. Cooroy, Queensland (Tryon).

This species has already been found in Queensland on leaves of *Elaeodendron* and *Myrtus*. Although in this instance it probably occurs as a saprophyte, it is suspected of being a parasite at times.

It is readily detected from the very black colour of the pustules.

*P. guepini* (Desm.) also occurs on Citrus leaves, but diseased leaves are not blistered or swollen in any way. It is known to be parasitic and very injurious to the Tea leaves in India and Ceylon. (Fig. 104.)

## III. FUNGI ON STEMS AND BRANCHES.

59. Corticium nudum.
60. Stictis radiata.
61. Gibberella pulicaris.
62. Oospora gemmata.
63. Cladosporium compactum.
64. Macrosporium commune.
65. Fusarium cryptum.
66. Fusarium incarnatum.
67. Fusarium limonis.
68. Fusarium sarcochroum.
69. Phoma citri.
70. Phoma macrophoma.
71. Phoma punctispora.
72. Phoma septobasidia.
73. Dothiorella limoni.
74. Ascochyta cinerea.
75. Ascochyta citricola.
76. Camarosporium citri.
77. Glœosporium citri.
78. Glœosporium intermixtum.

### 59. NAKED CORTICIUM.

(*Corticium nudum*, Fr.)

On twigs of Lisbon Lemon, killed by *Phoma omnivora* (McAlp.) September, 1898. South Australia.

Spores 11–15 × $3\frac{1}{2}$–$4\frac{1}{2}\mu$.

This fungus has already been recorded on the dead bark of an Orange tree at Rockhampton, Queensland. On some twigs it was quite tuberculate, on others more effused. (Fig. 125.)

### 60. RADIATING STICTIS.

(*Stictis radiata*, Pers.)

Gregarious or scattered, deeply immersed, urceolate, at first closed, then opening above and forming a reflexed white margin finely indented at various points, about $\frac{1}{2}$–$\frac{2}{3}$ mm. diam. Disc circular, slightly convex, pale orange-yellow. Asci cylindrical, when mature bulging about the middle, narrowing into slender pedicel at base, densely crowded, 8-spored, 120–130 × 5–$12\mu$.

Sporidia arranged in a fascicle with a slight twist, needle-shaped, hyaline, multiseptate, nearly the length of the ascus. Paraphyses equal throughout, numerous, hyaline, several septate, simple, filiform, just about length of ascus, $1\frac{1}{2}$–$2\mu$. broad (stained very pale yellow by Schulz's solution).

On dead twigs and thorns of Orange. July, 1899. Armada near Melbourne.

The cupules or ascophores resemble an Aecidium with the marg lacerated. They are sunk in the tissue of the bark with the wh border spread out and radiately split, and the disc when seen in favorable light is pale orange-yellow.

The asci when mature bulged considerably towards the midd reaching a breadth of $12\mu$.

It has only hitherto been recorded from Tasmania and Quee land. (Figs. 126, 127, 128, 129, 130.)

## 61. YELLOWISH-SPORED GIBBERELLA.

(*Gibberella pulicaris*, Sacc.)

Black erumpent pustules near to base of stem and seated up *Fusarium* either solitary or usually in black mulberry-like clust ($1\frac{1}{2}$mm.).

Perithecia sphaeroid or somewhat ovate, beautiful purplish-b by transmitted light; membranaceous, tough, with mini rounded apical pore, $170–260\mu$. diam., some even reaching 30 diam.

Asci elongated-clavate, shortly stalked, 8–spored, with paraphyses, $67–70 \times 10–13\mu$.

Sporidia 2-rowed, colourless, or with very faint tinge yellow, subfusoid, 3–septate, occasionally constricted at septu straight or somewhat curved, contents granular, $16–24 \times 5–9$ average $19–20 \times 6–7\mu$. (coloured yellowish-brown by potassiu iodide-iodine).

Stems of dying Lemon trees. October, 1898. Ardmo Victoria.

Stems of languid Orange trees. October, 1898. Doncast near Melbourne.

One perithecium, which seemed to be immature (Fig. 13 contained a bundle of radiating filaments (Fig. 133), hyaline, f ciculate, filiform, multiseptate, occasionally branched, with fin granular contents, usually tapering slightly towards apex, 32- $\times$ $2–4\mu$. (stained deep yellow by potassium-iodide-iodine).

This species is invariably associated with *Fusarium* which one case at least seemed to kill the tree. It spread considera underneath the bark, bursting through and causing it to cra and the caespitose perithecia were seated upon it.

*G. saubinettii* (Sacc.) has already been met with in Victoria herbaceous stems, and is difficult to separate from this speci but the characters are those of the above, except that the spori are a little narrower than in typical specimens.

*Conidial stage*—*Fusarium sambucinum* (Fckl.) is given by Saccardo, but this was certainly not the species found by me, and, as Tulasne has pointed out, there are probably several species found associated with it.

*Spermogonial stage*—*Phoma pulicaris* (Sacc.) is given by Saccardo, but I found associated with it a different species with punctiform sporules—*Phoma punctispora* n. sp., *Pycnidial stage.* (Figs. 131, 132, 133, 134, 135, 136.)

## 62. BUDDING OOSPORA.

(*Oospora gemmata,* n. sp.)

Hyphæ creeping, hyaline, moniliform, scanty, average $5\frac{1}{2}\mu$. broad, bearing conidia laterally and at apex in great abundance.

Conidia hyaline, elongated cylindrical, rounded at both ends, with granular contents, readily separating and budding freely in a yeast-like manner, average $13–15 \times 4–4\frac{1}{2}\mu$. On Lemon stem. Burnley, near Melbourne.

I have provisionally placed this in the genus *Oospora* on account of the scanty mycelium. *Monilia candida* (Bon) produces conidia which bud in a similar manner, but they are only $6–7\mu$. long. (Figs. 137, 138.)

## 63. COMPACT CLADOSPORIUM.

(*Cladosporium compactum,* Sacc.)

Forming minute, compact, crowded, punctiform tufts, giving dingy appearance to portions of dead twig affected.

Hyphæ densely fasciculate, olivaceous, septate, generally simple, occasionally forking towards base, average length $60–75\mu$., breadth $5\frac{1}{2}–7\frac{1}{2}\mu$.

Conidia similarly coloured, elongated-elliptical to fusiform, continuous or 1-septate, sometimes 3-septate, scarcely constricted at septa, smooth, average $11–13 \times 4\frac{1}{2}–5\frac{1}{2}\mu$., but may reach a length of $21\mu$., and when a-septate averaging $8 \times 4\mu$.

On dead twigs of Orange. October, 1898. Armadale, near Melbourne. The minute compact punctiform tufts resemble so many perithecia just appearing on the surface. It bursts through the epidermis and forms a very characteristic compact form on the surface.

It occurs on the leaves of the Lemon in Italy, and while Professor Penzig found the tufts superficial and not erumpent, the sections show that they burst through the outer layer of the bark. (Figs. 169, 170, 171.)

## 64. COMMON MACROSPORIUM.

(*Macrosporium commune,* Rabh.)

On dead tips of twigs of Lisbon Lemon. September, 1898. South Australia.

This species has only hitherto been recorded for Queensland.

## 65. HIDDEN FUSARIUM.

(*Fusarium cryptum,* n. sp.)

Sporodochia very minute, pale red, but seldom distinctly seen. Hyphæ hyaline, densely crowded, septate, constricted at septa, and often moniliform, sparingly branched, about $4\mu$. broad.

Conidia hyaline, slightly curved, blunt at both ends or at least at one end, 3-septate, average $19–22 \times 3\frac{1}{2}–4\mu$.

The sporodochium or spore-bed is intermixed and to a certain extent overlaid by the same olivaceous fungus associated with *Ascoctryta citricola,* so that it simply appears to the naked eye as a dark irregular incrustation.

The conidia are 3-septate, occasionally 1-septate, fairly regular in size and projecting at the margin of the crust. On dead twigs of Lisbon Lemon. September, 1898. South Australia (Quinn).

This is a very distinct species and does not agree with any of the recorded forms. The conidia are decidedly hyaline, very regular in size and shape, and never more than 3-septate. The specific name is given from the *Fusarium* being hidden by the olivaceous fungus. (Figs. 139, 140.)

## 66. FLESH-COLOURED FUSARIUM.

(*Fusarium incarnatum,* Desm.)

Sporodochia diffuse, white to flesh-coloured.

Hyphæ creeping, hyaline, septate, slender $2\mu$. broad.

Conidia produced at apex, colourless, fusiform to slightly falcate, bluntly pointed at both ends, generally 5-septate, but varying from 3–7 septate, not constricted at septa, $40–54 \times 3\text{-}5\mu$., average $45–49 \times 4\text{-}4\frac{1}{2}\mu$. On Lemon stems associated with *Gibberella pulicaris.* October, 1878. Ardmona, Victoria. July, 1899. Doncaster, near Melbourne. The Doncaster Lemon tree was dying from root-rot, and a portion of the bark was destroyed on one side near the collar. (Fig. 141.)

## 67. COLLAR-ROT FUSARIUM.

(*Fusarium limonis*, Briosi.)

Pustules gregarious, confluent, pale-straw colour, or forming effused slimy masses at margin of rotting collar. Hyphæ hyaline, flexuous, spreading, septate, branched, elongated, narrow, $1\frac{1}{2}$–$2\mu$. broad.

Conidiophores erect or ascending, branched alternately, opposite, or only on one side, bearing conidia at summit.

Conidia fusiform, crescent-shaped or straight, acute at each end or blunt, usually 3-septate, very slightly constricted at septa, sometimes aseptate, 1–2 or 4–5 septate, variable in size, 22–45 × 2–$4\mu$., average about 30 × $3\mu$.

At the collar of Orange and Lemon stems and extending into the roots, producing the disease known as "Collar-rot," "Foot-rot," or "Mal di gomma." All the year round. Common in Victoria, also in New South Wales, Queensland, and South Australia. Specimen from Doncaster. 28th August, 1896. Recorded for the first time in Australia.

The Sweet Orange (*Citrus aurantium*, L. var. *dulcis*) and Lemon (*Citrus medica*, L. var. *limonium*) are specially liable to this disease, while the Sour or Seville Orange (*C. aurantium*, L. var. *bigaradia*) and the Pomelo and Shaddock (*C. aurantium*, L. var. *decumana*) are much more resistant than the Sweet Orange or the Lemon.

The cause of this disease is still in dispute, but the contagious nature of it seems to point to some parasitic organism. Briosi, who first named and described the above fungus in Italy has always found it to accompany the disease, but it is difficult to say if it is the primary cause. He adds, however—"I do not believe there can be any doubt that its presence accelerates the disorganization of the tissues and aids in extending the disease." I have also invariably found it penetrating the diseased tissues with its long slender wandering filaments.

Numerous conidia were found in active germination, protruding filaments at either end or laterally from the segments. (Plates XI., XII., and Figs. 142, 143, 144, 145.)

## 68. FLESHY FUSARIUM.

(*Fusarium sarcochroum*, Sacc.)

Sporodochia minute, coral pink, convex, erumpent, about $\frac{1}{3}$ mm. diam., or in widely effused patches more ruddy, even ferruginous in colour, and rupturing bark.

Hyphæ pale pink collectively, densely fasciculate, septate, repeatedly dichotomously branched, $3\frac{1}{2}$–$4\frac{1}{2}\mu$. broad.

Conidia hyaline, fusiform, straight or slightly curved, acute at both ends, produced at the tips of the branches, contents finely granular, 1–3 septate, rather variable in length, but pretty constant in breadth, 29–41$\mu$. (stained canary-yellow by Potassium-iodide-iodine).

On bark just above root of languid Orange trees, also on bark of Lemon trees. October–February. Doncaster, near Melbourne. Trees were brought under my notice as having some bark disease, and the above species was found splitting the bark and injuriously affecting the trees. It is evidently, at least in some cases, an injurious parasite, but it has only hitherto been observed on a few trees. Penzig is also inclined to regard it as a parasite, since it occurs on still living branches. As an instance of variability in size the two extremes (29–41$\mu$. long) were found alongside of each other.

*Gibberella pulicaris* (Sacc.) was seated upon it. (Figs. 167, 168.)

## 69. CITRUS PHOMA.

(*Phoma citri*, Sacc.)

Forming densly crowded minute pustules giving a silvery-grey appearance to dead twigs.

Perithecia sublenticular, depressed, immersed and slightly elevating cortex, finally erumpent and very black, with round, scarcely papillate mouth, about 200$\mu$. diam.

Sporules elongated elliptical to subfusoid, hyaline, bi-guttulate $8\frac{1}{2}$–$9\frac{1}{2} \times 2\frac{1}{2}$–$3\mu$., basidia long, crowded, hyaline, guttulate, 20–30$\mu$.

On dead twigs of Orange practically all the year round. October to August. Armadale, near Melbourne. (Figs. 146, 147, 148.)

## 70. LARGE-SPORED PHOMA.

(*Phoma macrophoma*, n. sp.)

Minute, punctiform, immersed pustules on dirty-grey to dirty-white bark of Orange twig.

Perithecia gregarious, dark-brown by transmitted light, depressed globose, covered by epidermis with apical pore, texture parenchymatous, 150–180$\mu$., and pore averaging 18$\mu$. diam.

Sporules hyaline, oblong, rounded at both ends and often tapering slightly towards one end, with granular contents, $13\frac{1}{2}$-$14\frac{1}{2} \times 3\frac{1}{2}$–$4\frac{1}{2}\mu$., basidia cylindrical, continuous, simple, averaging $15 \times 2\mu$.

On branch of Orange and Lemon. October, 1893. Lancaster, Victoria. The discolouration of the bark is very marked, especially where adjoining the ordinary green tissue, and while the bark actually invaded by the fungus is of a dirty white, the surrounding tissue may become blackish.

The grower who sent the specimen notes that it begins as a small black spot, and when it gets right round a limb the top dies off. It also attacks Lemons in the same way, and several have died apparently from this cause.

The sporules are just on the boundary line between those recognised as belonging to *Phoma* and *Macrophoma*, and this is indicated in the specific name. (Figs. 149, 150, 151, 152.)

## 71. MINUTE PHOMA.

(*Phoma punctispora*, n. sp.)

Associated with and probably a spermogonial stage of *Gibberella pulicaris* (Sacc.).

Perithecia sub-globose, brown, without definite texture, minute, about 40$\mu$. diam.

Sporules very minute, hyaline, punctiform, about 1$\mu$. diam. (coloured very pale yellow by potassium-iodide-iodine).

On stem of dying Lisbon Lemon, along with *Fusarium* and *Gibberella pulicaris*. October, 1898. Ardmona, Victoria.

Very few perithecia were seen, but they might very easily be overlooked on account of their small size. The sporules are quite distinct from those of *P pulicaris*, which are oblong, curved, and 4 × 1–1½$\mu$. (Fig. 153.)

## 72. SEPTATE PHOMA.

(*Phoma septo-basidia*, n. sp.)

Forming minute, gregarious, black points, on grey bark of dead Orange twig.

Perithecia immersed, dark-brown by transmitted light, flattened-globose, membranaceous, very brittle, of parenchymatous texture, with circular mouth (34–37$\mu$. diam.), closely incorporated with matrix at the base, up to 260–330$\mu$. broad.

Sporules hyaline, cylindrical to elongated-fusoid, usually biguttulate, 8–12 × 2–2½$\mu$.; basidia hyaline, at least 1-septate, crowded, filiform, tapering slightly at apex, 20–25 × 1½$\mu$.

On Orange twigs. July, 1899. Armadale, near Melbourne.

Associated with *Phoma omnivora* (McAlp.), which is readily distinguished by its much smaller and erumpent perithecia. It differs from *P. citri* (Sacc.) and *P. scabella* (Penz.) in the longer and narrower sporules, and the septate basidia. (Figs 154, 155, 156, 157.)

## 73. LEMON DOTHIORELLA.

(*Dothiorella limoni*, n. sp.)

Forming dark-coloured dots on the still green bark of Lemon twigs.

Perithecia erumpent, then superficial, bright olive-green, composite; individual perithecia sub-globular, membranaceous, variable in size, with apical pore, 112–150 × 90–120$\mu$.

Sporules hyaline, oval to elongated-elliptic, somewhat variable in size, 8–11 × $3\frac{1}{2}$–$4\frac{1}{2}\mu$.

On Lemon twigs. October, 1898. Doncaster, Victoria.

The ends of the shoots were decorticated and dead, but on the still green basal portion the perithecia were found. The perithecia are not very striking to the naked eye. Two species of this genus are recorded on the bark of Orange—*D. guaranitica* (Speg.) has rather large sporules, 24–26 × 12–15$\mu$., and *D. placenta*, with obovate sporules, 15$\mu$. long. (Figs. 158, 159.)

## 74. ASHY ASCOCHYTA.

(*Ascochyta cinerea*, n. sp.)

Forming ashy-grey patches on dead twigs.

Perithecia gregarious, densely crowded, immersed, black, membranaceous, 150–200$\mu$.

Sporules greenish in mass, and agglutinated together, colourless individually, elongated elliptic, 1–septate, not constricted at septa, rounded at both ends, 11–14 × 4–$4\frac{1}{2}\mu$.

On dead Orange twigs. 1898. Armadale, near Melbourne. On Lemon twigs, Lancaster, Victoria.

The sporules in the early stages, and while still unicellular are pale green, but when fully mature and bicellular are usually colourless. Potassium-iodide-iodine intensifies the green colour of the young sporules, and gives a faint tinge of green to the otherwise colourless mature sporules.

It differs from *A. hesperidearum* (Penz.) in the sporules being rounded at the ends, and not at all fusoid, and in forming pallid patches on the twigs. (Figs. 160, 161, 162.)

## 75. BARK BLOTCH ASCOCHYTA.

(*Ascochyta corticola*, n. sp.)

Minute, brownish to blackish, densely gregarious, punctiform pustules, round or often elongated lengthwise, and slightly elevating the ruptured cortex.

Perithecia erumpent, yellowish-brown to dark-brown by transmitted light, depressed globose to elongated lens-shaped, membranaceous, variable in size, 170–300$\mu$., apical pore elongated to round, average 15$\mu$. diam., and bordered by slightly darker cells.

Sporules hyaline, cylindrical, straight, 1-septate, not constricted at septum, sometimes 1-guttulate, 8–12 × 2–3$\mu$.

On Lemon stems. September and October, 1897. Lancaster, Victoria. October, 1898, April, 1899. Ardmona, Victoria.

On decorticated wood of Orange. October, 1893. Lancaster, Victoria.

The sporules are generally narrower than those of *A. citricola* and *A. cinerea*. Perithecia generally agree in colour with bark, so that they are difficult to detect with the naked eye.

This fungus is the cause of a disease affecting a great many trees, particularly Lemons, in the districts mentioned. It starts about the collar as a brownish-black spot, working all round and up the stem till it eventually kills the tree. It may then appear on the decorticated wood, as in the case of the Orange.

Several fungi were found associated with this species, viz., *Fusarium incarnatum* (Desm.), *Gibberella pulicaris* (Sacc.) *Phoma macrophoma*, n. sp., and *Phoma punctispora*, n. sp. (Plates IX., X., and Figs. 163, 164.)

## 76. CITRUS CAMAROSPORIUM.

(*Camarosporium citri*, n. sp.)

Large, black, erumpent pustules on dirty-grey dead Orange twigs, along with *Stictis radiata* (Pers.).

Perithecia gregarious, sub-coriaceous, depressed lenticular, at first covered, then erumpent, finally superficial, ¾mm. long, with circular mouth.

Sporules very numerous, golden brown, oblong or ovoid-oblong, 3-septate, with longitudinal septa, constricted at septa, somewhat variable in shape, 15–19 × 9–11$\mu$., average 17 × 9$\mu$.

On Orange twig. August, 1899. Armadale, near Melbourne.

This species was remarkable for the large size of the perithecia, which ultimately became quite superficial. (Figs. 165, 166.)

## 77. CITRUS GLŒOSPORIUM.

(*Glœosporium citri*, Cooke and Mass.)

Gregarious, erumpent, pale fuliginous.

Pustules rather small, often confluent, cuticle splitting irregularly above.

Conidia obtusely fusiform, on short conidiophores, at first nucleate or granular, hyaline, 20 × 5–6$\mu$.

On branches of Lemon. Victoria (Mrs. Martin).

## 78. INTERMIXED GLŒOSPORIUM.

(*Glœosporium intermixtum*, n. sp.)

Pustules scattered, erumpent, surrounded by ruptured epidermis, minute, intermixed with and generally concealed by dense tufts of *Cladosporium compactum* (Sacc.).

Conidia hyaline, elliptic to elongated-elliptic, with granular contents, often 2–3-guttulate, 7–12 × 3–3½μ., average 7–8 × 3–3½μ.; basidia hyaline, short, filiform.

On dead Orange twig. October, 1898. Armadale, near Melbourne.

It differs from *G. depressum* (Penz.) in the pustules not being depressed, and the basidia being relatively short.

The hyphæ of the *Cladosporium* often overrun the surface before the emergence of the *Glœosporium*, so that the upturned epidermis is covered by it. (Fig. 172.)

## IV—FUNGI ON ROOTS.

79. Septocylindrium radicicolum.

## 79. ROOT SEPTOCYLINDRIUM.

(*Septocylindrium radicicolum*, n. sp.)

Forming downy-white patches on roots.

Hyphæ densely interwoven, hyaline, simple, septate, comparatively narrow at base (2½μ.), and expanding to breadth of conidia at top, longer or shorter before producing conidia at apex, up to 70μ. long.

Conidia hyaline, cylindrical, 3-septate, not constricted at septa, produced in long chains, 20–34 × 4½–5½, average 28 × 5μ.

On roots of Lemon affected with "Root-rot." July, 1899. Doncaster, near Melbourne.

It differs from *S. bonordenii* (Sacc.) in the usually distinct hyphæ, and in the conidia being regularly 3-septate and broader.

There were also similar white patches on the root consisting of densely interwoven, hyaline, regularly segmented, branching, barren filaments, often with fusiform branches at right angles, which were readily detached and probably multiplied the fungus. (See Fig. 176.)

All these fungi were saprophytic on the otherwise unhealthy roots. (Figs. 173, 174, 175, 176.)

## V.—FUNGI ON SCALE INSECTS.

80. Fusarium epicoccum.
81. Microcera coccophila.
82. Microcera rectispora.

## 80. COCCUS FUSARIUM.

(*Fusarium epicoccum*, n. sp.)

Growing round margin and on top of Red Scale, *Aspidiotus aurantii* (Mask), pale brick-red, usually forming crescent-shaped effused masses, visible to naked eye.

Hyphæ hyaline, septate, branched, slender, $2\frac{1}{2}$–$3\frac{1}{2}\mu$. broad.

Conidia colourless, sickle-shaped, sometimes straight, acute at both ends, produced apically or from joints, 1–3–septate, 17–19 × $2\frac{1}{2}\mu$.

On Red Scale on branches of Mandarin Orange. August. Burnley, near Melbourne.

In *F. larvarum* (Fckl.) the conidia are $24\mu$. long and twice as broad.

Very few specimens of this species were obtained, so that its further history was not traced. (Figs. 177, 178, 179, 180.)

## 81. COCCUS TUBERCLE.

(*Microcera coccophila*, Desm.)

Minute, deep brick-red tubercles, rounded or flattened and disc-like on surface, usually in small groups, visible to naked eye, hard and horny when dry, with short stem-like base.

Hyphæ at base of conidiophores hyaline, septate, closely compacted, 3-$4\mu$. broad.

Conidiophores tufted, filiform, elongated (at least $280\mu$.) septate, sometimes slightly constricted at septa, rose-pink in mass, with finely granular and often vacuolated contents, 4–$4\frac{1}{2}\mu$. broad.

Conidia same colour as conidiophores to hyaline, curved, elongated, usually blunter at free end than attached end, with finely granular, nucleated contents, variously septate, continuous up to 8-septate, average 5–6, size from tip to tip of curve, and not actual length, 75–103 × $5\frac{1}{2}$–$8\frac{1}{2}\mu$.

Parasitic on Red Scale of Orange and Shaddock, *Aspidiotus coccineus* (Gennad). July, August, &c. Botanic Gardens, Sydney, New South Wales (Maiden). On Coccus infesting the Lemon. Queensland (Bailey). (Figs. 181, 182).

## 82. ORANGE COCCUS TUBERCLE.

(*Microcera rectispora*, Cooke and Mass.)

Tufts rather sphaeroid, almost sessile, at first reddish, at length pallid.

Conidia elongated-fusiform, acute at each end, 7–9 septate, straight, hyaline, 150–200 × $10\mu$.

Conidiophores short, thin, furcate, hyaline.

On Coccus of Orange (*Chionaspis citri*, Comst., or "White Louse"). Queensland (Bailey). (Figs. 183, 184, after Cooke.)

## GENERAL REMARKS ON TREATMENT.

In the accompanying chart of the principal fungus diseases and their treatment simple instructions are given for dealing with the different diseases mentioned, as far as our present knowledge will permit, but it is not to be for a moment imagined that the whole duty of the Citrus-grower consists in providing himself with a spraying outfit, and dressing his trees with various chemical mixtures. The health of a tree, like the health of a human being, is due to various factors, and none of them must be neglected if the best results are to be obtained. Hence a suitable soil should be chosen for planting an orchard, as well as a good situation. Proper cultivation, attention to drainage and watering and manuring when necessary, should be given in addition to spraying when circumstances demand it.

*Manuring.*—It has been found in America, especially in Florida, where the Orange soils are mostly sandy and sterile, that manuring is not only necessary for healthy growth, but for the prevention of many diseases to which Citrus-trees are subject. In a paper by Mr. Webber on "Fertilization of the soil as affecting the Orange in health an disease," published in the Year-book of the U.S. Department of Agriculture for 1894, the subject has been very fully discussed, and the results are summarized as follows:— "Fertilization has an important bearing on diseases. Die-back, a serious malady, is in all probability the result of over-feeding with nitrogenous manures from organic sources. These manures, if used at all, should be applied with great caution. Foot-rot, although not primarily due to improper methods of fertilization, is no doubt considerably influenced by this cause. Insect diseases are also apparently influenced by the use of fertilizers, organic manures rendering the trees more liable to injury from this source than chemical fertilizers."

Lime soils are considered superior for Orange growing in many Orange countries, on account of their effect on the quality of the fruit and its earlier ripening.

*Spraying.*—The best time for spraying is early in the spring, just before the bloom-buds burst. If the disease is very bad, another is useful when the fruit is set sufficiently to bear the force of the spray. The autumn is also a good time, when the weather is cool and the sun is not too hot. The frequency of the spraying will largely depend upon the nature and virulence of the disease.

*Removal of diseased bark, branches, &c.*—Several fungus diseases seriously affect the bark and ultimately destroy the tree. If the disease is taken in time, and the affected bark completely cut away and burnt, recovery may take place. The green bark seems to heal rapidly, and a fresh vigorous growth is set up. In

"Wither-tip," the shoots affected should be cut away during the pruning season, and destroyed by burning, since the minute spores may readily be carried by the wind or other agency and start the disease afresh.

*Hybridizing.*—In the United States numerous experiments have been made in hybridizing Orange and other Citrus trees to secure, if possible, disease-proof varieties. "Another important problem in Citrus culture which has received attention during the past year is to secure a common Orange of good quality, with the loose, easily-removable rind of the tangierine Orange, and also to secure sorts resistant to blight and other diseases" (Year-book of the United States Department of Agriculture, 1898). Other experiments in hybridizing have been carried out to get a hardy Orange which will resist the severe frosts and freezes to which such fruits are subjected in Florida and California, and this has been attempted by crossing the common Orange with the Japanese hedge Orange or trifoliate Orange, which is a hardy sort, though of poor quality. This species is already grown in Australia, but being deciduous it might not prove quite suitable as a stock for evergreen trees. There are several native species, however, which might well repay attention on the part of the cultivator. (Appendix 1.)

In conclusion, it cannot be too strongly impressed on growers that co-operation in dealing with plant diseases is absolutely essential for complete success. Just as thistle-down may spread from a neighbouring dirty field to a clean one, so the spores of a parasitic fungus may be carried by the wind or other agency to an orchard where every reasonable precaution is taken to guard against disease, and thus the efforts to check disease may be neutralized or, at any rate, rendered more difficult. Prevention is better than cure, and co-operation renders it sure.

It may seem rather discouraging to the Citrus-grower that he may have so many fungus diseases to fight, but if the danger which threatens him leads to cleaner cultivation and to a regular system of treatment which will not only prevent disease, but improve the quantity and quality of the fruit, then the knowledge of the existence of such formidable foes will have served as an incentive to progress and a spur to exertion.

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## EXPLANATION OF TERMS.

*Ascus* (plural Asci) is the little bag containing sporidia enclosed within a larger case or perithecium.

*Bacteriosis* is the name given to the class of diseases produced by the minute micro-organisms generally known as bacteria.

*Basidium* (plural Basidia), a slender filament at the end of which the spore is borne.

*Conidium* (plural Conidia) is the reproductive cell produced free, and not enclosed in any sort of case. The word refers to their dust-like character, as they are usually found in large numbers.

*Conidiophore* is the hypha or fungus-filament directly bearing the conidia.

*Echinulate*, beset with short spines.

*Erumpent*, bursting through the surface.

*Fasciculate*, forming a bundle or tuft.

*Fusiform*, spindle-shaped.

*Gregarious*, growing in groups.

*Guttulate*, with spherical drops or guttæ.

*Habitat*, the place in which a plant grows.

*Hypha* (plural Hyphæ) is a Greek word for a thread, and the name is given to the fine threads or filaments which usually branch and form a network.

$\mu$ is the first letter of the Greek word *micron*, and represents $\frac{1}{1000}$ th of a millimetre or about $\frac{1}{25000}$ th inch.

*Membranaceous*, thin and soft, and more or less transparent.

*Mycelium* is the name given to the vegetative portion of the fungus, and consists of the entire branching network of hyphæ.

*Papilla*, a nipple-like projection.

*Paraphyses* are the slender sterile threads which accompany the Asci, and may be regarded as packing material.

*Parasite*, an organism living in or upon and at the expense of another.

*Perithecium* is the capsule surrounding and enclosing the asci.

*Pycnidium* is the case containing the spores when not enclosed in asci, although the term perithecium is often used in the same sense.

*Reticulated*, forming a network.

*Saprophyte*, an organism living upon dead organic matter.

*Septum* (plural Septa) is the partition-wall between different cells of the filaments of a fungus or of a spore.

*Spore* is a reproductive body, analogous to the seed of a plant which becomes free, and is capable of reproducing the species. Conidia, sporules, and sporidia are special names given for convenience to spores according to their mode of production.

*Sporidia* is the name given to reproductive bodies contained in asci.

*Sporodochium* or spore-bed is the closely woven layer of filaments bearing the conidia in such a genus as *Fusarium*.

*Sporule* is the term applied to a reproductive body contained in a perithecium but not enclosed in an ascus.

# NATURE, HABITAT, AND DISTRIBUTION OF FUNGI.

| Name. | Parasite or Saprophyte. | Habitat. | Australian Distribution. |
|---|---|---|---|
| Ascochyta cinerea ... | S. | Lemon—twigs ... | V. |
| Ascochyta citricola ... | P. | Orange and Lemon—leaves and twigs | S.A., V. |
| Ascochyta corticola ... | P. | Orange & Lemon—stems | V. |
| Aspergillus glaucus ... | S. | Lemon ... ... | V. |
| Bacteriosis ... ... | P. | Lemons—ripe ... | V. |
| Camarosporium citri ... | S. | Orange—twigs ... | V |
| Capnodium citricolum ... | S. | Orange and Lemon—fruit, leaves, branches | W.A., S.A., V., N.S.W., Q. |
| Cladosporium brunneo-atrum | P. | Orange—fruit, leaves, and twigs | N.S.W. |
| Cladosporium furfuraceum | P. | Lemons ... ... | V. |
| Cladosporium compactum ... | S. | Orange—dead twigs ... | V. |
| Cladosporium corrugatum | P. | Orange—leaves—green | V. |
| Cladosporium elegans ... | P. | Orange—leaves—green | V. |
| Cladosporium herbarum ... | S. | Orange—leaf ... .. | V. |
| Cladosporium subfusoideum | P. | Lemons ... ... | V., N.S.W. |
| Clasterosporium citri ... | S. | Lemon—leaves—languid | V. |
| Colletotrichum glœosporioides | S. | Orange and Lemon—leaves and twigs | V., Q., |
| Coniothecium citri ... | P. | Orange—leaf ... ... | V. |
| Coniothecium scabrum ... | P. | Oranges and Shaddocks—green | V. |
| Coniothyrium cervinum ... | P. | Lisbon Lemon—leaves... | V. |
| Coniothyrium citricolum ... | P. | Orange—living leaves ... | V. |
| Corticium nudum ... | S. | Lemon & Orange—twigs | S.A., Q. |
| Diplodia citricola ... | S. | Lemons and Citrons—fruit, leaves, and stem | V. |
| Diplodia destruens ... | P. | Orange and Lemon—leaves | S.A., V. |
| Dothiorella federata ... | S. | Lemon—leaves ... | V. |
| Dothiorella limoni ... | P. | Lemon—twigs ... | V. |
| Epicoccum granulatum ... | S. | Lemon—leaves ... | V. |
| Eurotium herbariorum ... | S. | Lemons—decaying ... | V. |
| Fusarium cryptum ... | S. | Lisbon Lemon—dead twigs | S.A. |
| Fusarium epicoccum ... | P. | Red scale on Mandarin Orange | V |
| Fusarium epithele ... | S. | Lemon—on warts ... | N.S.W. |
| Fusarium incarnatum ... | S. | Lemon—stems ... | V |
| Fusarium limonis ... | P. | Orange and Lemon—stems | S.A., V., N.S.W., Q. |
| Fusarium roseum ... | S. | Orange and Lemon—leaf and twigs | V |
| Fusarium sarcochroum ... | P. | Orange & Lemon—stems | V. |
| Gibberella pulicaris ... | S. | Orange & Lemon—stems | V. |
| Glœosporium citri ... | S. | Lemon—branches .. | V |
| Glœosporium citricolum ... | S. | Orange—leaves ... | Q. |
| Glœosporium intermixtum | S. | Orange—twig ... | V |
| Glœosporium tenuisporum | S. | Orange—leaf ... ... | V. |
| Hendersonia citri ... | P. | Bitter Orange—leaf ... | V. |
| Hendersonia socia ... | S. | Lemon—leaf and stem... | V. |
| Heterosporium variabile ... | P. | Knight's Citron—leaf ... | V |

NATURE, HABITAT, AND DISTRIBUTION OF FUNGI—*continued.*

| Name. | Parasite or Saprophyte. | Habitat. | Australian Distribution. |
|---|---|---|---|
| Macrosporium citri ... | P. | Lemon—leaves ... | S.A. |
| Macrosporium commune ... | S. | Lisbon Lemon—twigs... | S.A. |
| Macrosporium disruptum | P. | Orange—leaves—green | V. |
| Microcera coccophila ... | P. | Scale of Orange, Lemon, and Shaddock | N.S.W., Q. |
| Microcera rectispora ... | P. | White Louse of Orange | Q. |
| Monilia rosella ... ... | S. | Lemons—decaying ... | V. |
| Oospora gemmata ... | S. | Lemon—stem ... | V. |
| Ovularia aurantii ... | P. | Oranges (imported from Italy) | V |
| Ovularia citri ... ... | P. | Lemons—ripe ... | N.S.W. |
| Penicillium glaucum ... | S. | Oranges and Lemons—decaying | Common everywhere |
| Penicillium italicum ... | S. | Oranges—decaying | V |
| Pestalozzia funerea ... | S. | Lemon — leaves — with scab | Q. |
| Phoma citri ... ... | S. | Orange—dead twigs ... | V. |
| Phoma citricarpa ... | P. | Oranges, Lemons, and Mandarins | N.S.W. |
| Phoma flaccida ... ... | P. | Orange—leaves ... | V. |
| Phoma macrophoma ... | P. | Orange and Lemon—branches | V. |
| Phoma hesperidum ... | S. | Orange and Lemon—leaves and stem | V |
| Phoma omnivora ... | P. | Oranges, Lemons, and Citrons—fruit, leaves, stems, and roots | W.A., S.A., V., N.S.W. |
| Phoma punctispora ... | S. | Lisbon Lemon—stem ... | V. |
| Phoma rhodospora ... | S. | Lemon—leaves ... | V |
| Phoma septo-basidia ... | S. | Orange—twigs ... | V. |
| Phyllosticta hesperidearum | P. | Orange & Lemon—leaves | V. |
| Phyllosticta longispora ... | P. | Orange—green leaves ... | V. |
| Phyllosticta scabiosa ... | P. | Lemon—leaf ... ... | Q. |
| Pleospora disrupta ... | P. | Orange—green leaves ... | V |
| Pleospora herbarum ... | S. | Orange and Lemon—leaves and twigs | V |
| Pleospora limonum ... | P. | Lemon—leaves—languid | V. |
| Pyrenochæta aurantii ... | P. | Orange — with "False Melanose" | N.S.W. |
| Pyrenochæta destructiva ... | P. | Bitter Orange and Shaddock—leaves | V |
| Ramularia scabiosa ... | P. | Orange & Lemon—leaves | Q. |
| Septocylindrium radicicolum | S. | Lemon—roots ... | V |
| Septoria depressa ... | P. | Lemons ... ... | V. |
| Septoria flaccescens ... | P. | Orange—leaves ... | V. |
| Septoria westraliensis ... | S. | Orange—leaves ... | W.A. |
| Sphaerella citricola ... | S. | Lemon—leaf ... ... | Q. |
| Sphaerella sicula ... | S. | Orange—leaf ... ... | V. |
| Sphæropsis citricola ... | S. | Lemon—fruit, leaf, and stem | V., N.S.W., Q. |
| Sporodesmium griseum ... | P. | Oranges & Lemons—ripe | N.S.W. |
| Sporodesmium triseptatum | S. | Lemon—leaf ... ... | Q. |
| Stictis radiata ... ... | S. | Orange—dead twigs ... | V. |

# APPENDIX 1.

## I. CITRUS SPECIES CULTIVATED IN AUSTRALIA.

Citrus aurantium, L.—var. bergamia, Risso—Bergamot Orange.
var. bigaradia, Loisel—Bitter Orange.
var. decumana, Murr.—Pomelo and Shaddock.
var. dulcis, Pers.—Sweet Orange.
var. nobilis, Lour.—Mandarin or Tangierine.
Citrus japonica, Thun.—Cumquat.
Citrus medica, L.—var. cedra, Link—Citron.
var. limetta, Risso—Lime
var. limonum, Risso—Lemon.
var. lumia, Risso—Sweet Lemon.
Citrus trifoliata, L.—Trifoliate-leaved Orange or Hedge-lemon of Japan.

## II. NATIVE CITRUS SPECIES.

Citrus australasica, F. v. M.—Finger-lime.
Citrus australis, Planch.—Native Orange.
Citrus inodora, Bail.—Queensland Lime.

With reference to this last species, Mr. Bailey remarks—"This new species of Citrus is well worthy of cultivation for its fruit, which is juicy and of equal flavour with the West Indian Lime."

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# APPENDIX 2.

*Letter from L. O. Howard, Ph. D.*

United States Department of Agriculture,
Division of Entomology,
Washington, D.C.,
26th November, 1898.

Dear Sir,

Your letter of the 10th of October, asking for the description of a method of treatment for nursery stock which will insure the destruction of insects in any stage, and of fungus diseases, duly received. I regret to inform you that an absolutely reliable and universally effective means of disinfection of nursery stock has not been discovered. The gas treatment can be used at a very great strength on dormant nursery stock, but it will not, as a rule, kill the eggs of insects, especially where they may be protected by overlying more or less impenetrable matter, as beneath the dead mother scales in the case of Coccidæ. It is, therefore, by far the most effective means of disinfection now known. Many plants can be immersed in water at a temperature above 150° Fahrenheit for several minutes without particular injury to the plant, and this treatment is even recommended for disinfection from certain insects. Where it can be practised it is probably even more efficacious than gas. It is used in this country for the treatment of root stock presumably infested with root lice.

In the matter of plant diseases I am not an authority, but undoubtedly there are diseases which invade the tissues of the plant, and which no treatment short of the pruning knife or fire will remedy, and as they are not always discoverable in the early stages, an absolute preventive of introduction by inspection and treatment is necessarily impossible. The long experience with the hydrocyanic acid gas in California has early demonstrated its practical efficiency, even though absolute certainty of protection does not necessarily follow its use. If all plants which are not open to especial suspicion are fumigated, and all plants which are evidently infested, or notably so, are burned, the danger of introduction of insect pests will be reduced to a minimum.

Yours truly,
L. O. HOWARD, Entomologist.

## APPENDIX 3.

### VICTORIA.

RETURN showing the quantity and value of Oranges and Lemons imported into the colony of Victoria, and the countries whence imported, during the years 1897 and 1898 :—

| Where from. | Quantity. | Value. |
|---|---|---|
| Oranges and Lemons* | Year | 1897. |
| United Kingdom ... ... ... | 945 bushels | £337 |
| Other Australian colonies— | | |
| (Produce of Australia) ... .. | 183,698 ,, | 31,800 |
| (Produce other) ... ... ... | 2,068 ,, | 482 |
| Italy ... ... ... ... | 26,080 ,, | 9,365 |
| Other foreign countries ... ... | 741 ,, | 230 |
| Total ... ... | 213,532 bushels | £42,214 |
| Oranges— | Year | 1898. |
| Other Australian colonies— | | |
| (Australian produce) ... ... | 259,839 bushels | £47,436 |
| (Other produce) ... ... ... | 1,119 ,, | 342 |
| Italy ... ... ... ... | 8,027 ,, | 2,834 |
| Other foreign countries ... ... | 5 ,, | 2 |
| Total ... ... | 268,990 bushels | £50,614 |
| Lemons— | Year | 1898. |
| Other Australian colonies— | | |
| (Australian produce) ... ... | 18,758 bushels | £3,119 |
| (Other produce) ... ... ... | 1,327 ,, | 503 |
| Italy ... ... ... ... | 19,311 ,, | 8,027 |
| Other foreign countries ... ... | 635 ,, | 235 |
| Total ... ... | 40,031 bushels | £11,884 |

* Oranges and Lemons were not shown separately in 1897.

H. N. P. WOLLASTON,
Secretary for Trade and Customs.

Department of Trade and Customs,
Melbourne, 8th June, 1899.

# EXPLANATION OF PLATES.

## PLATE XIII.

### Capnodium citricolum.

Fig. 1. Coloured hyphæ, some of them bearing conidia (× 1,000).
Fig. 2. Pycnidia and pycnospores (× 540).
Fig. 3. Perithecium (× 145).

## PLATE XIV.

### Capnodium citricolum—*continued.*

Fig. 4. Asci containing ascospores (× 1,000).

### Eurotium herbariorum.

Fig. 5. Perithecium (× 270).
Fig. 6. Asci with clusters of sporidia and sporidia seen from different angles (× 1,000).

### Pyrenochaeta aurantii.

Fig. 7. Perithecium with spines surrounding mouth (× 270).
Fig. 8. Spines (× 1,000).
Fig. 9. Sporules (× 1,000).
Fig. 10. Cladosporium and Macrosporium-like conidia associated with it (× 1,000).

### Monilia rosella.

Fig. 11. Hyphæ bearing conidia (× 1,000).
Fig. 12. Conidia detached and in chains (× 1,000).

### Ovularia aurantii.

Fig. 13. Hyphæ with conidia attached (× 1,000).
Fig. 14. Conidia detached and mature (× 1,000).

## PLATE XV.

### Ovularia citri.

Fig. 15. Terminal portion of hypha (× 1,000).
Fig. 16. Conidia attached (× 1,000).

### Cladosporium brunneo-atrum.

Fig. 17. Branching hyphæ (× 540).
Fig. 18. Conidia attached and detached (× 1,000).

### Cladosporium furfuraceum.

Fig. 19. Hyphæ constricted and not constricted at septa (× 1,000).
Fig. 20. Conidia (× 1,000).

### Cladosporium subfusoideum.

Fig. 21. Conidia (× 1,000).
Fig. 22. Sporodesmium-like conidia often associated (× 1,000).

### Sporodesmium griseum.

Fig. 23. Hyphæ of various forms with Cladosporium-like conidia (× 1,000).

## PLATE XVI.

Fig. 24. Multiseptate conidia and sometimes with longitudinal septa (× 1,000).

### CONIOTHECIUM SCABRUM.

Fig. 25. Portion of pale-green hypha (× 1,000).
Fig. 26. Portion of darker green hypha (×1,000).
Fig. 27. Portion of greenish-brown filament, and terminal part dark-brown (× 1,000).
Fig. 28. Cladosporium-like conidia (× 1,000).
Fig. 29. Longer and larger conidia (× 1,000).
Fig. 30. Cruciately to radiately septate conidia (× 270).

### FUSARIUM EPITHELE.

Fig. 31. Conidia (× 1,000).

### PHOMA CITRICARPA.

Fig. 32. Perithecium—surface view (× 145).
Fig. 33. Section of perithecium (× 145).
Fig. 34. Sporules (× 1,000).

## PLATE XVII.

### PHOMA OMNIVORA.

Fig. 35. Perithecium—side view (× 145).
Fig. 36. Perithecium—side view (× 270).
Fig. 37. Perithecium—oblique view (× 270).
Fig. 38. Section of leaf with perithecium (× 270).
Fig. 39. Mass of sporules as they escape from perithecium (× 270).
Fig. 40. Sporules (× 1,000).

## PLATE XVIII.

### SPHAEROPSIS CITRICOLA.

Fig. 41. Perithecium—surface view (× 145).
Fig. 42. Sporules drawn in groups to show average size (× 1,000).

### DIPLODIA CITRICOLA.

Fig. 43. Perithecium—surface view (× 145).
Fig. 44. Sporules, mature and immature, and in different groups, to show how they naturally occurred (× 1,000).

### SEPTORIA DEPRESSA.

Fig. 45. Perithecium—surface view (× 270).
Fig. 46. Sporules (× 1,000).
Fig. 47. Sporules of *S. glaucescens* (× 1,000).

## PLATE XIX.

### SPHAERELLA CITRICOLA.

Fig. 48. Perithecium—surface view (× 270).
Fig. 49. Ascus and sporidia, immature and mature (× 1,000).

### PLEOSPORA DISRUPTA.

Fig. 50. Perithecium, surface view (× 270).
Fig. 51. Perithecium burst, showing asci (× 270).
Fig. 52. Sporidium (× 1,000).

## PLATE XIX.—*continued.*

PLEOSPORA HERBARUM.

Fig. 53. Ascus containing 8 sporidia (× 540).

SPHAERELLA SICULA.

Fig. 54. Group of perithecia—surface view (× 145).
Fig. 55. Ascus containing sporidia and one detached (× 1,000).

RAMULARIA SCABIOSA.

Fig. 56. Conidia (× 1,000).

CLADOSPORIUM CORRUGATUM.

Fig. 57. Hyphæ and conidia (× 1,000).

## PLATE XX.

CLADOSPORIUM ELEGANS.

Fig. 58. Hyphæ with conidia at apex (× 540).
Fig. 59. Conidia (× 1,000).

HETEROSPORIUM VARIABILE.

Fig. 60. Hyphæ (× 1,000).
Fig. 61. Conidia at different stages of development and one germinating (× 1,000).

SPORODESMIUM TRISEPTATUM.

Fig. 62. Hyphæ arising from dense dark-brown layer (× 1,000).
Fig. 63. Hyphæ with colourless to pale-green conidia (× 1,000).
Fig. 64. Yellowish-green to brown conidia (× 1,000).
Fig. 65. Conidia of Sporodesmium—stage (× 1,000).

CONIOTHECIUM CITRI.

Fig. 66. Short creeping hypha (× 1,000).
Fig. 67. Cluster of conidia (× 540).

MACROSPORIUM CITRI.

Fig. 68. Hyphæ, branched and unbranched (× 1,000).

## PLATE XXI.

MACROSPORIUM CITRI—*continued.*

Fig. 69. Conidia and different stages of development (× 1,000).

MACROSPORIUM DISRUPTUM.

Fig. 70. Cladosporium—stage with small conidia (× 1,000).
Fig. 71. Cladosporium—stage with large echinulate conidia, one of which is germinating (× 1,000).
Fig. 72. Conidium of Macrosporium—stage (× 1,000).

FUSARIUM ROSEUM.

Fig. 73. Branching hypha and conidia (× 1,000).

## PLATE XXII.

### Phyllosticta hesperidearum.

Fig. 74. Perithecium—surface view (× 145).
Fig. 75. Perithecium in section (× 145).
Fig. 76. Sporules (× 1,000).

### Phyllosticta longispora.

Fig. 77. Perithecia—surface view (× 145).
Fig. 78. Sporules (× 1,000).

### Phyllosticta scabiosa.

Fig. 79. Perithecium—surface view (× 270).
Fig. 80. Sporules (× 1,000).

### Phoma flaccida.

Fig. 81. Perithecium—surface view (× 145).
Fig. 82. Sporules—one with basidium attached (× 1,000).

### Pyrenochaeta destructiva.

Fig. 83. Two perithecia—surface view (× 145).
Fig. 84. Spine and basal portion (× 1,000).
Fig. 85. Sporules (× 1,000).
Fig. 86. Cladosporium—conidia associated with perithecium (× 1,000).

## PLATE XXIII.

### Coniothyrium citricolum.

Fig. 87. Perithecium—surface view (× 270).
Fig. 88. Sporules (× 1,000).

### Diplodia destruens.

Fig. 89. Perithecium—surface view (× 145).
Fig. 90. Sporules (× 1,000).

### Ascochyta citricola.

Fig. 91. Perithecium—surface view (×270).
Fig. 92. Sporules (× 1,000).

### Hendersonia citri.

Fig. 93. Two perithecia—surface view (× 270).
Fig. 94. Sporules (× 1,000).

### Hendersonia socia.

Fig. 95. Two perithecia (× 145).
Fig. 96. Sporules, some immature still attached to basidia (× 1,000).

### Septoria Flaccescens.

Fig. 97. Perithecium—surface view (× 270).
Fig. 98. Sporules (× 1,000).

### Septoria westraliensis.

Fig. 99. Perithecium—surface view (× 145).
Fig. 100. Sporules (× 1,000).

## PLATE XXIV.

### Glœosporium tenuisporum.

Fig. 101. Conidia (× 1,000).

### Colletotrichum glœosporioides.

Fig. 102. Bristle (× 1,000).
Fig. 103. Conidia (× 1,000).

### Pestalozzia funerea.

Fig. 104. Conidia (× 1,000).

### Epicoccum granulatum.

Fig. 105. Surface view of sporodochia (× 52).
Fig. 106. Section of stroma bearing conidia (× 270).
Fig. 107. Conidium (× 1,000).

### Phoma rhodospora.

Fig. 108. Perithecia—surface view (× 145).
Fig. 109. Sporules (× 1,000).

### Dothiorella federata.

Fig. 110. Pustule (× 145).
Fig. 111. Perithecia—surface view (× 270).
Fig. 112. Sporules (× 1,000).

### Coniothyrium cervinum.

Fig. 113. Perithecium—surface view (× 270).
Fig. 114. Sporules (× 1,000).

## PLATE XXV.

### Pleospora media.

Fig. 115. Perithecia—surface view (× 145).
Fig. 116. Parenchymatous texture of perithecuim (× 1,000).
Fig. 117. Ascus with sporidia and paraphyses (× 1,000).
Fig, 118. Immature colourless uniseptate sporidia (× 1,000).
Fig. 119. Slender thick-jointed hyphæ inside immature perithecium (× 1,000).
Fig. 120. Group of perithecia (4) of *Phoma omnivora* associated with large perithecuim of *P. media* (× 52).

### Phoma hesperidum.

Fig. 121. Perithecium—surface view (× 145).
Fig. 122. Sporules (× 1,000).

### Clasterosporium citri.

Fig. 123. Hyphæ branching and creeping (× 1,000).
Fig. 124. Conidium (× 1,000).

## PLATE XXVI.

### Corticium nudum.

Fig. 125. Spores (× 1,000).

### Stictis radiata.

Fig. 126. Fungus on portion of dead twig (nat. size).
Fig. 127. Three ascophores—surface view (× 52).
Fig. 128. Immature asci (× 1,000).
Fig. 129. Mature ascus and paraphyses (× 1,000).
Fig. 130. Sporidium (× 1,000).

### Gibberella pulicaris.

Fig. 131. Three perithecia (× 145).
Fig. 132. Immature perithecium burst, showing bundles of radiating filaments (× 145).
Fig. 133. Radiating branching filaments (× 1,000).

## PLATE XXVII.

### Gibberella pulicaris—*continued.*

Fig. 134. Ascus containing eight sporidia.
Fig. 135. Sporidia (× 1,000).
Fig. 136. Sporidium germinating (× 1,000).

### Oospora gemmata.

Fig. 137. Hypha with conidia attached in chains (× 1,000).
Fig. 138. Conidia budding in a yeast-like manner (× 1,000).

### Fuasrium cryptum.

Fig. 139. Conidia in chains attached to hypha (× 1,000).
Fig. 140. Conidia detached (× 1,000).

### Fusarium incarnatum.

Fig. 141. Conidia (× 1,000).

### Fusarium limonis.

Fig. 142 Portion of hypha (× 1,000).
Fig. 143. Hyphæ with conidia attached (× 1,000).
Fig. 144. Conidia of various sizes detached (× 1,000).
Fig. 145. Conidia germinating (× 1,000).

## PLATE XXVIII.

### Phoma citri.

Fig. 146. Perithecium—surface view (× 145).
Fig. 147. Sporules with basidia (× 1,000).
Fig. 148. Sporules detached (× 1,000).

### Phoma macrophoma.

Fig. 149. Perithecium—surface view (× 270).
Fig. 150. Section of perithecia (× 270).
Fig. 151. Parenchymatous texture of perithecium (× 1,000).
Fig. 152. Sporules (× 1,000).

## PLATE XXVIII.—*continued.*

### Phoma punctispora.

Fig. 153. Perithecium emitting punctiform sporules (× 145).

### Phoma septo-basidia.

Fig. 154. Perithecium—surface view (× 145).
Fig. 155. Perithecium in section (× 145).
Fig. 156. Parenchymatous texture of perithecium (× 1,000).
Fig. 157. Sporules and septate basidia (× 1,000).

### Dothiorella limoni.

Fig. 158. Perithecium (× 540).
Fig. 159. Sporules (× 1,000).

## PLATE XXIX.

### Ascochyta cinerea.

Fig. 160. Three perithecia (× 145).
Fig. 161. Perithecium—surface view (× 270).
Fig. 162. Sporules (× 1,000).

### Ascochyta corticola.

Fig. 163. Two perithecia (× 270).
Fig. 164. Sporules (× 1,000).

### Camarosporium citri.

Fig. 165. Perithecia—surface view (× 52).
Fig. 166. Sporules (× 1,000).

### Fusarium sarcochroum.

Fig. 167. Dichotomously branching hyphæ, bearing conidia at their tips (× 1,000).
Fig. 168. Detached conidia, straight and slightly curved (× 1,000).

### Cladosporium compactum.

Fig. 169. Section through outer bark, showing erumpent tuft of hyphæ (× 540).
Fig. 170. Hyphæ (× 1,000).
Fig. 171. Conidia detached (× 1,000).

### Glœosporium intermixtum.

Fig. 172. Conidia (× 1,000).

## PLATE XXX.

### Septocylindrium radicicolum.

Fig. 173. Hypha with conidia in chains (× 540).
Fig. 174. Very short hypha producing conidium (× 1,000).
Fig. 175. Conidia (× 1,000).
Fig. 176. Hypha with fusiform branches belonging to some other mould (× 1,000).

## PLATE XXX.—*continued.*

### Fusarium epicoccum.

Fig. 177. Portion of shield of red scale with protruding hyphæ bearing conidia (× 145).

Fig. 178. Hyphæ branching and bearing conidia apically and laterally (× 1,000).

Fig. 179. Conidia detached (× 1,000).

Fig. 180. Pale-brown triradiate body belonging to Sooty Mould (× 1,000).

### Microcera coccophila.

Fig. 181. Hypha with conidia attached (× 1,000).

Fig. 182. Conidia detached (× 1,000).

### Microcera rectispora.

Fig. 183. Tubercle (nat. size).

Fig. 184. Four conidia magnified, and one conidium (× 400).

## PLATE XXXI.

### Pyrenochæta aurantii.

Fig. 185. Pycnidium showing bristles around mouth and seated on a stratum of hyphæ (× 70).

### Phoma citricarpa.

Fig. 186. Section through skin of lemon, with two pycnidia, one mature the other immature (× 70).

# INDEX OF COMMON AND SCIENTIFIC NAMES OF FUNGI.

## Index of Common and Scientific Names of Fungi—*continued.*

INDEX OF COMMON AND SCIENTIFIC NAMES OF FUNGI—*continued*.

### Index of Common and Scientific Names of Fungi—*continued.*



By Authority: Robt. S. Brain, Government Printer, Melbourne.

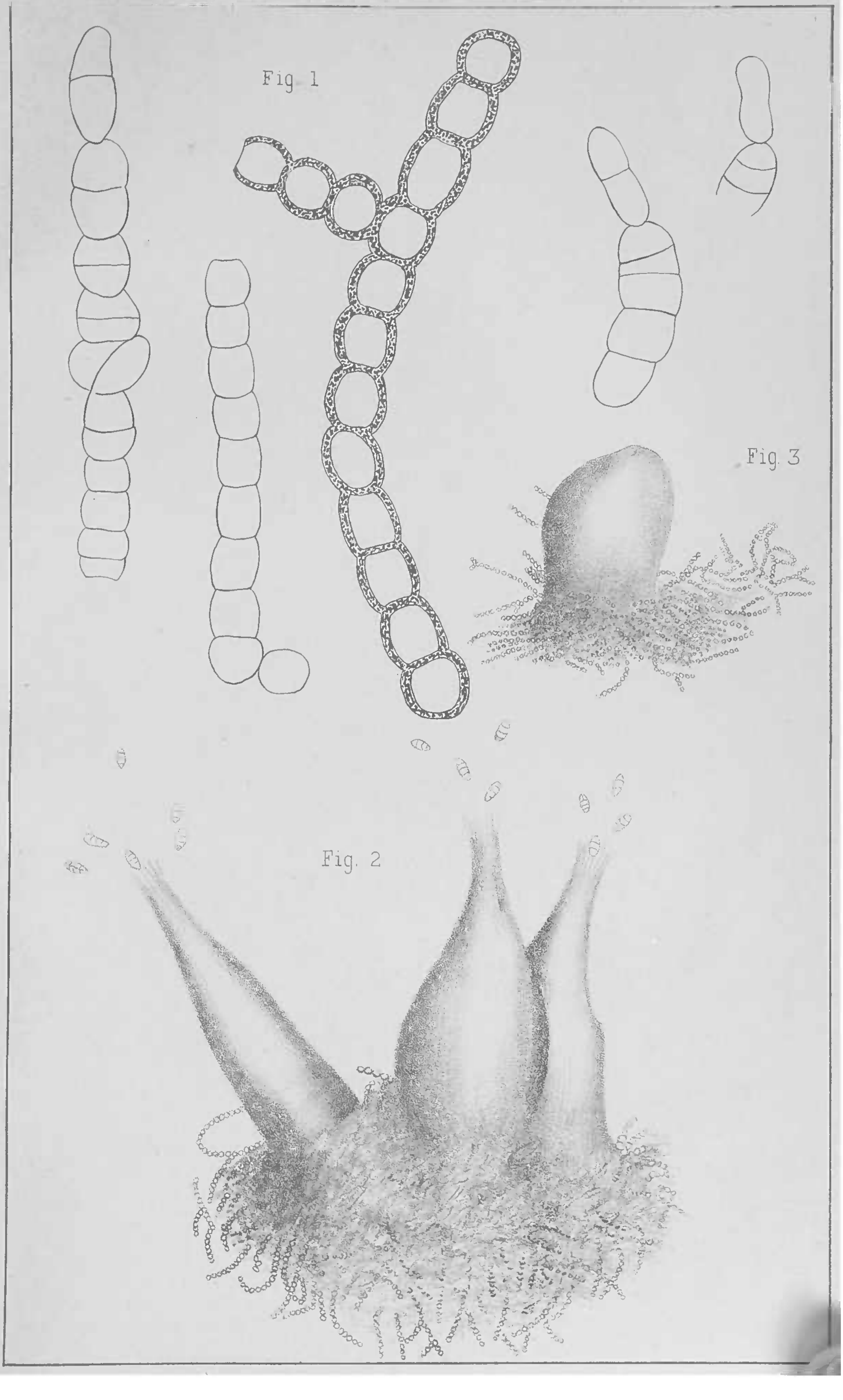
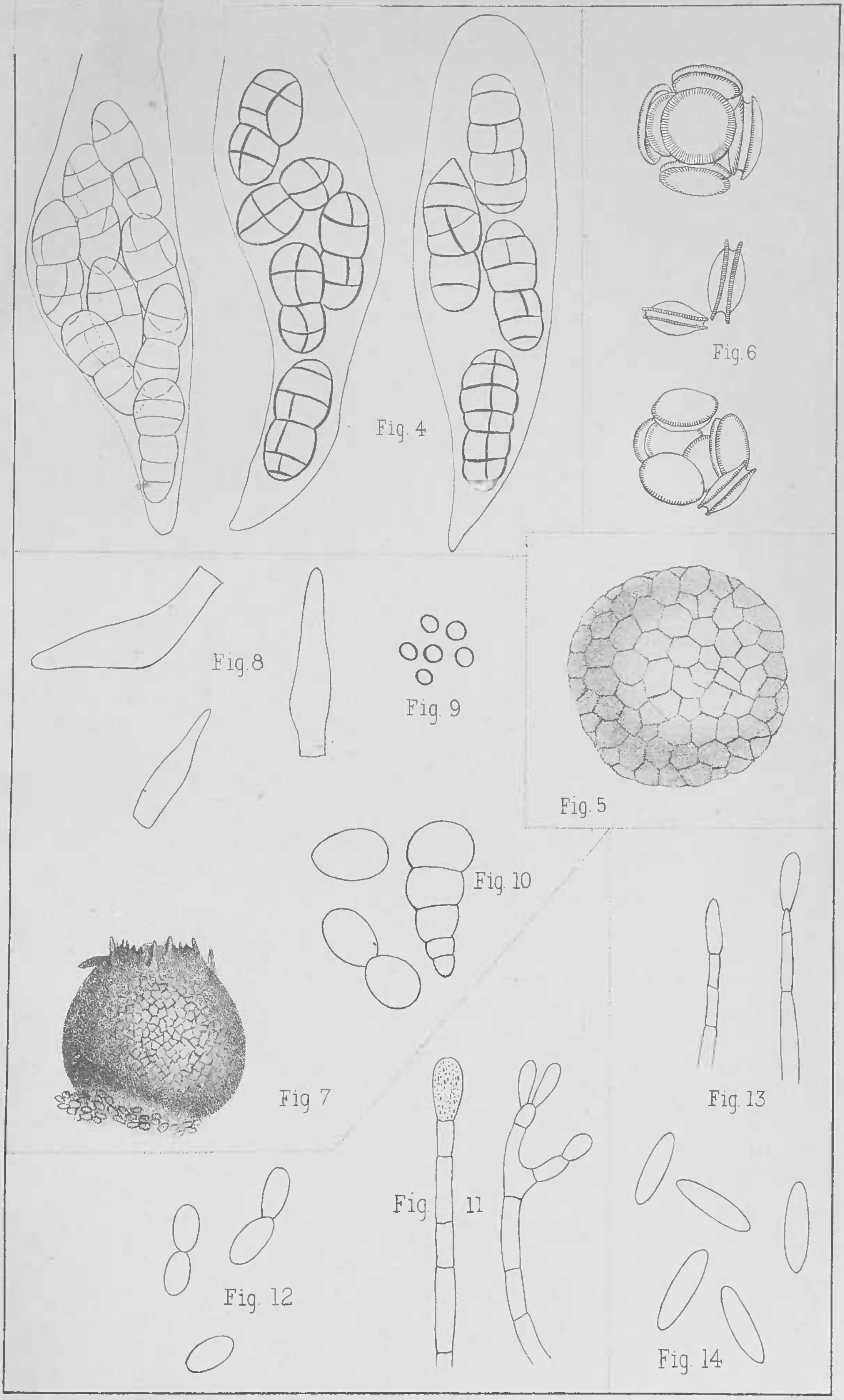
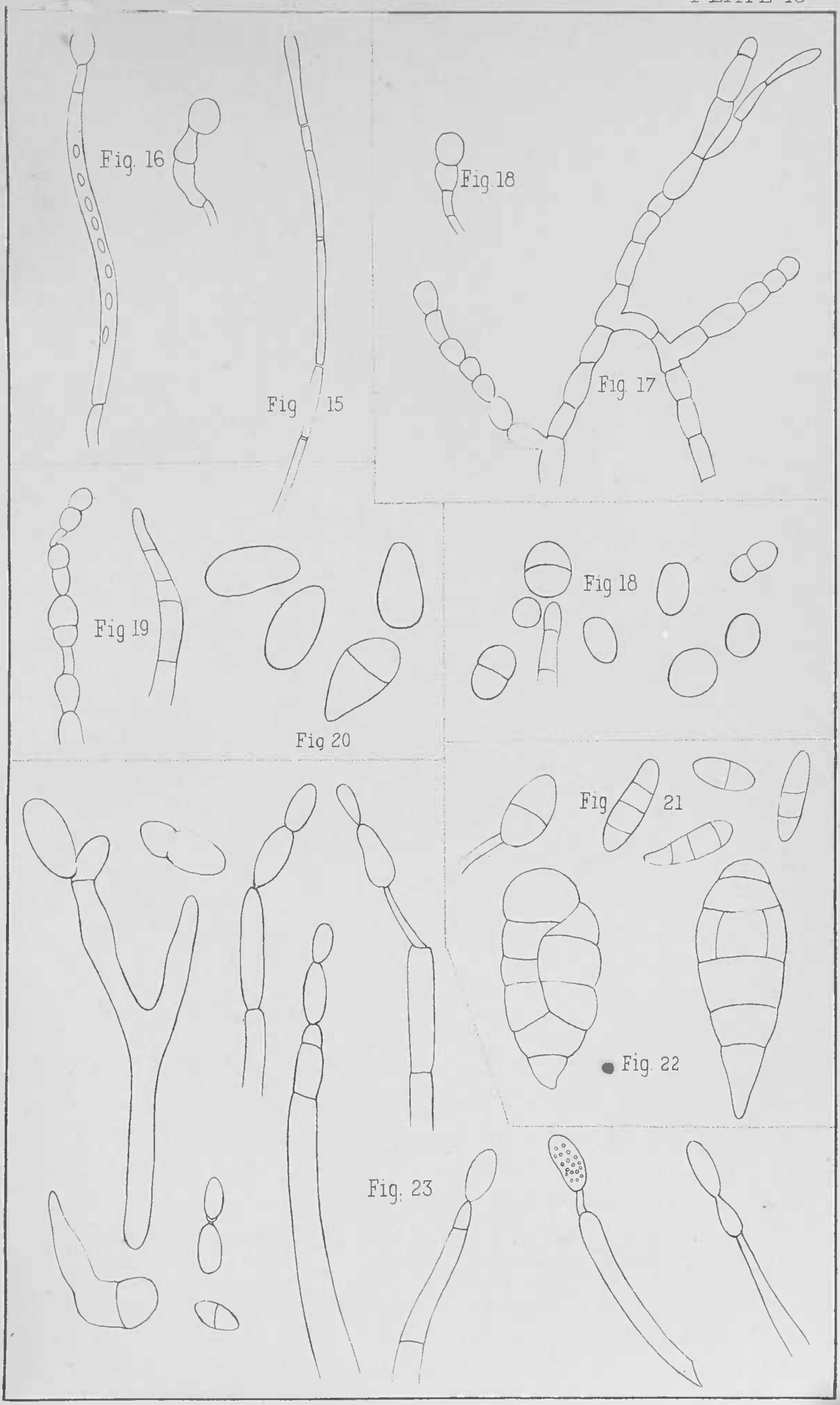


Fig. 1
Fig. 3
Fig. 2

PLATE 14

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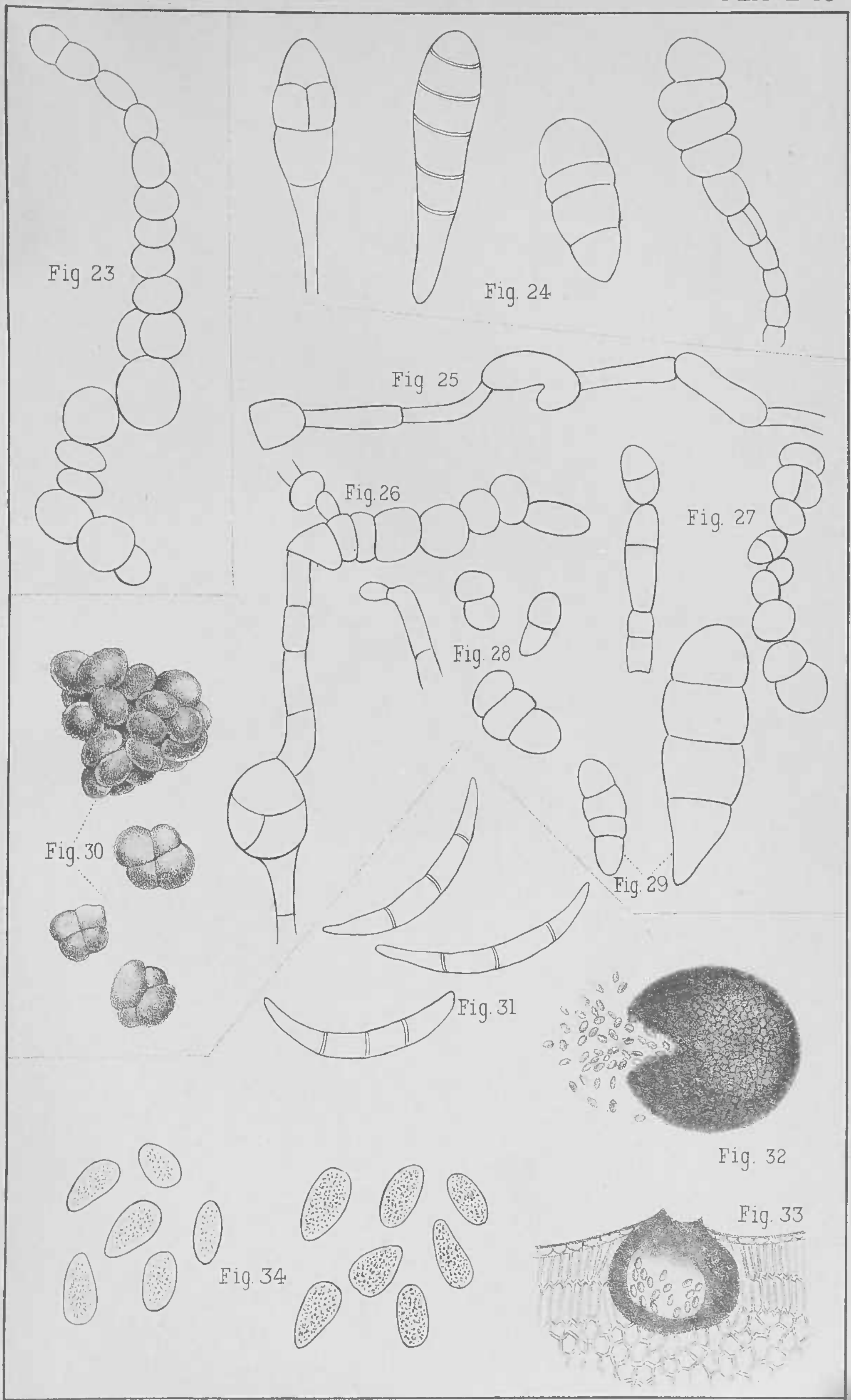
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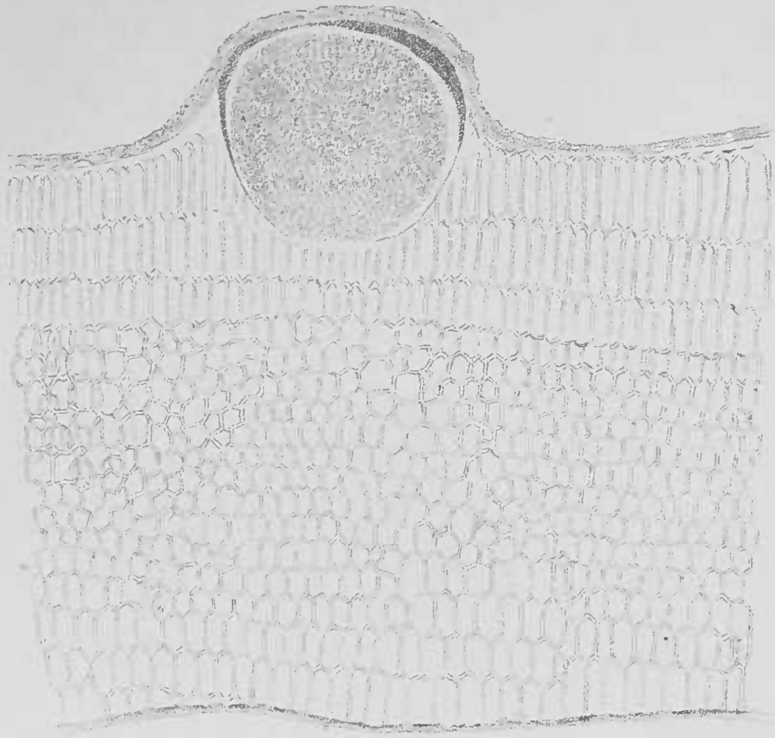

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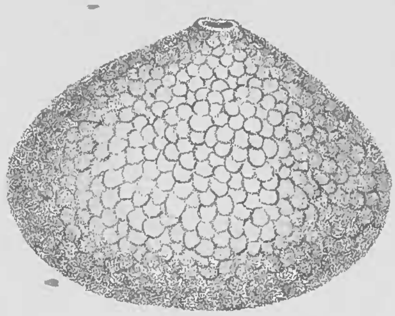

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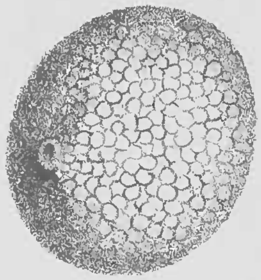
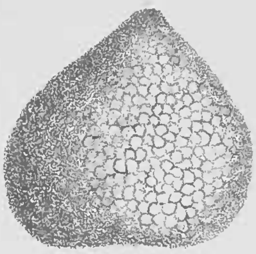


Fig. 37

Fig. 40



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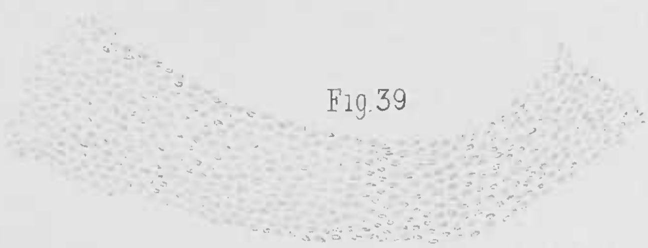

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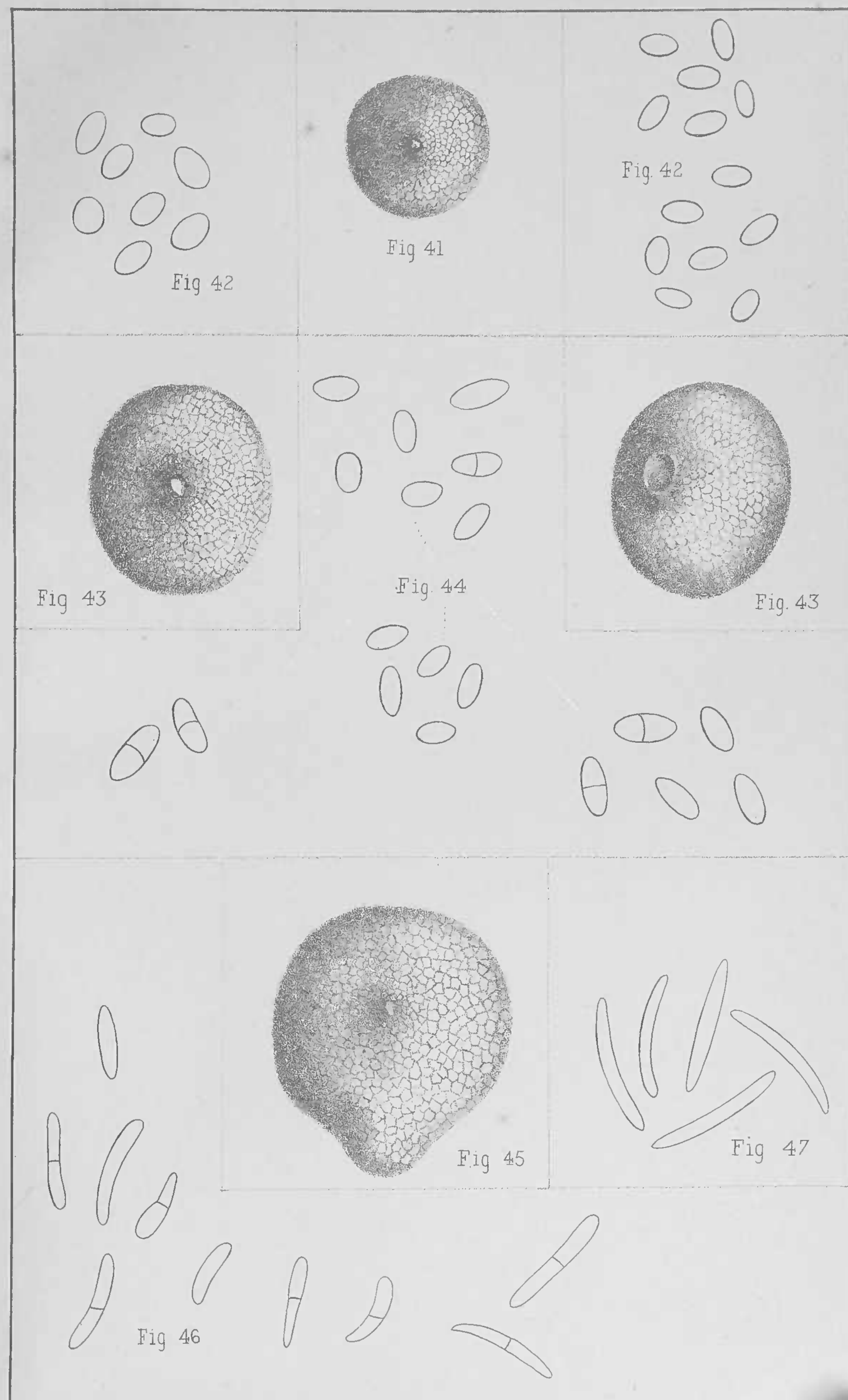
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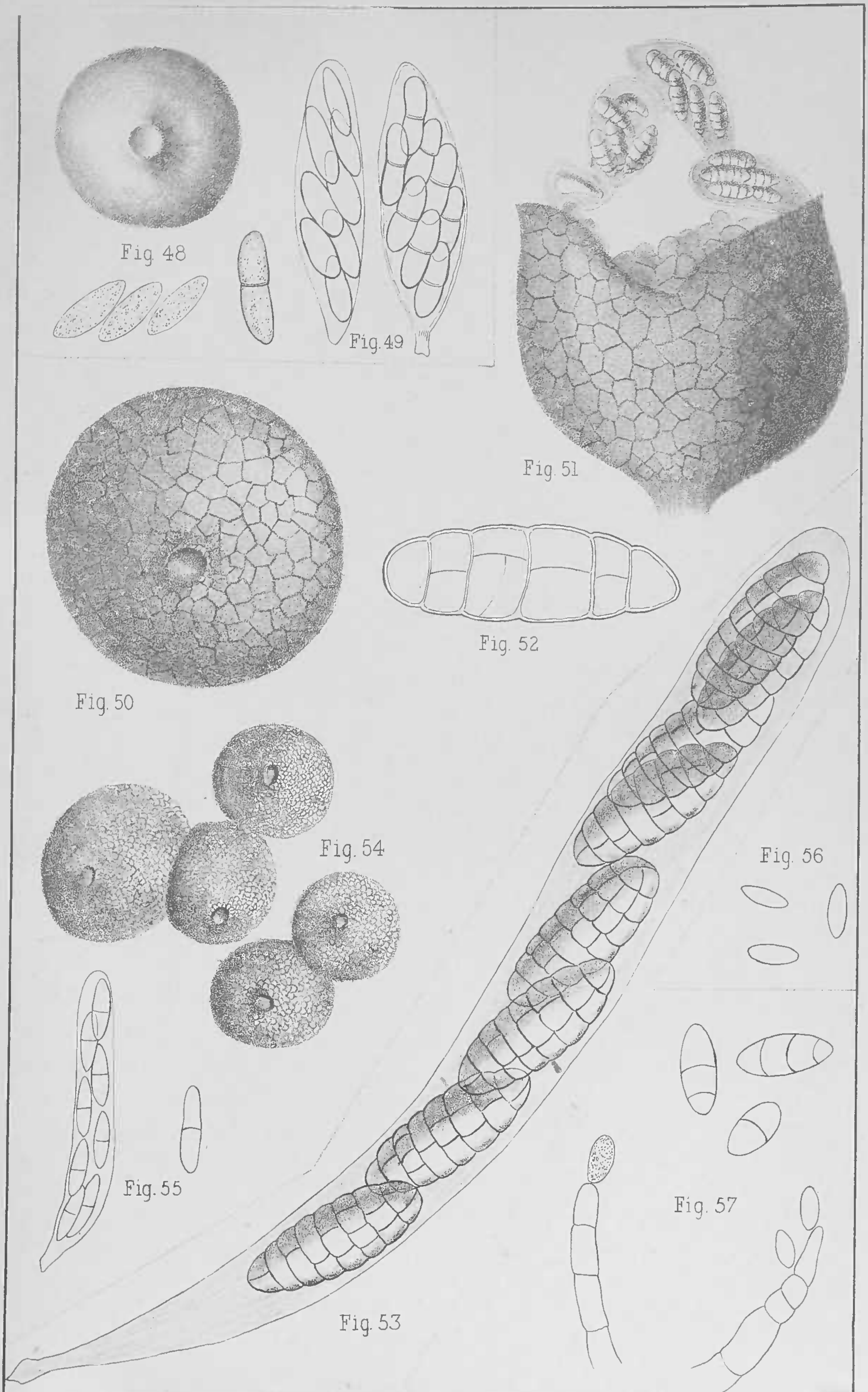
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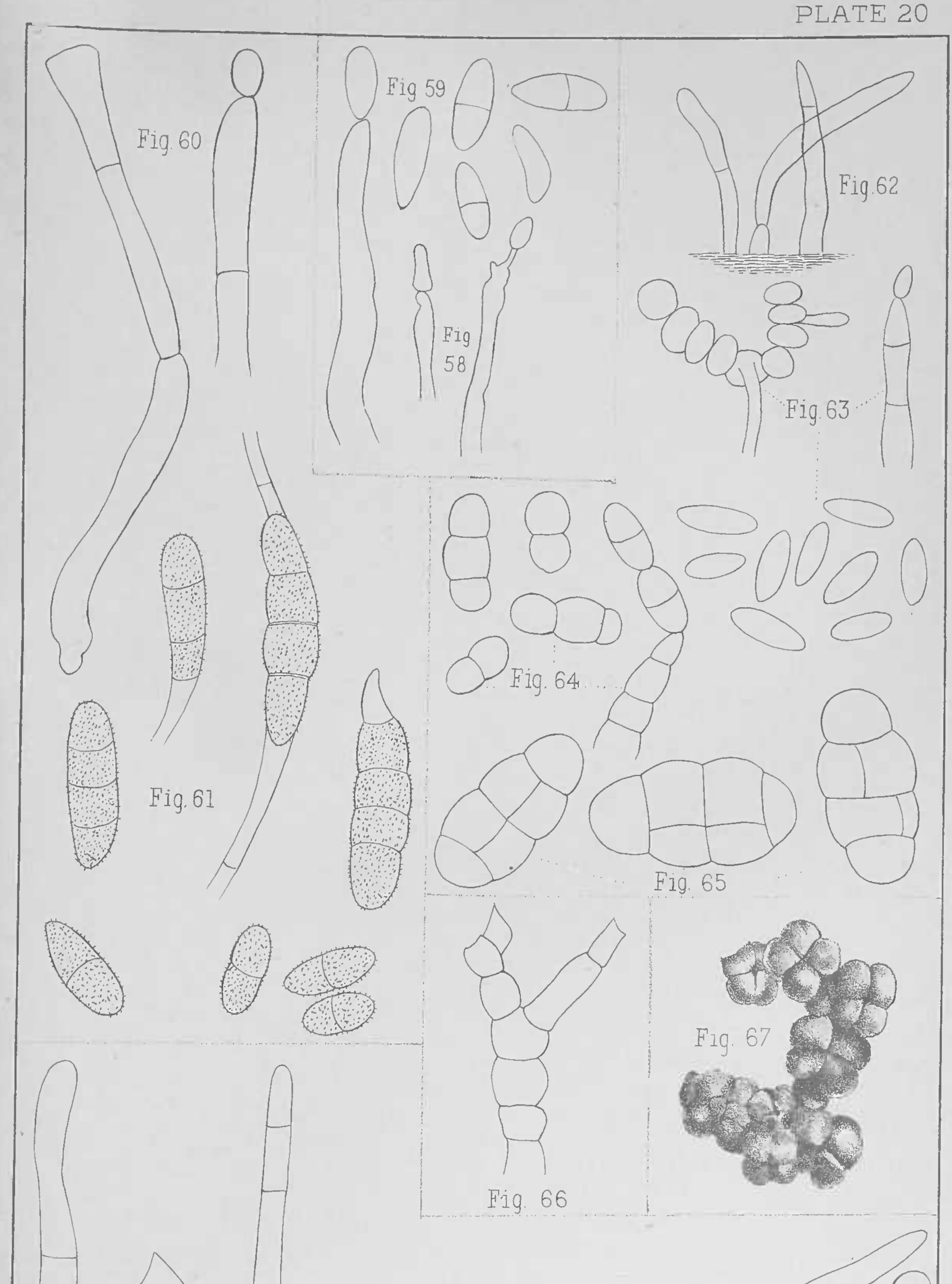
PLATE 20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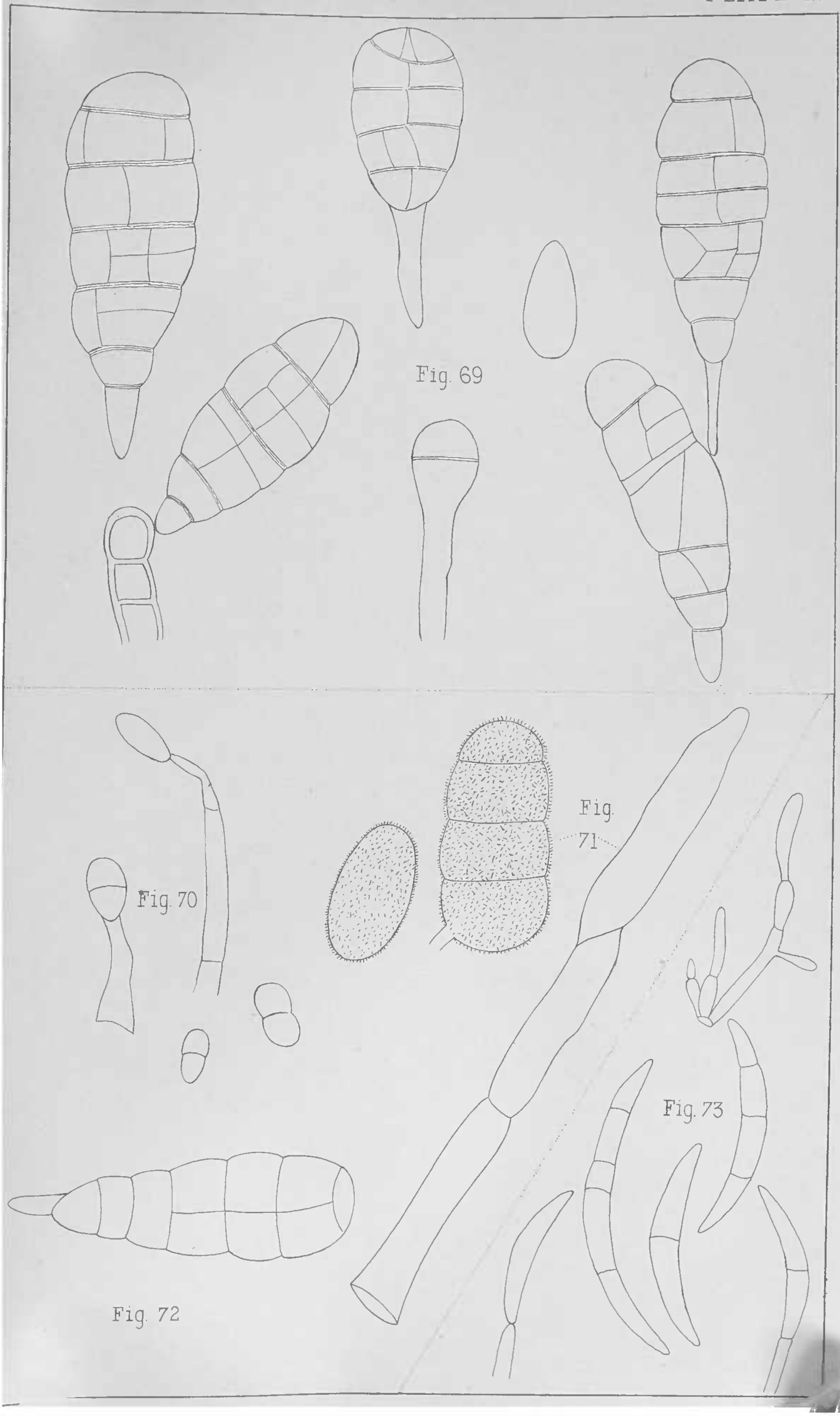
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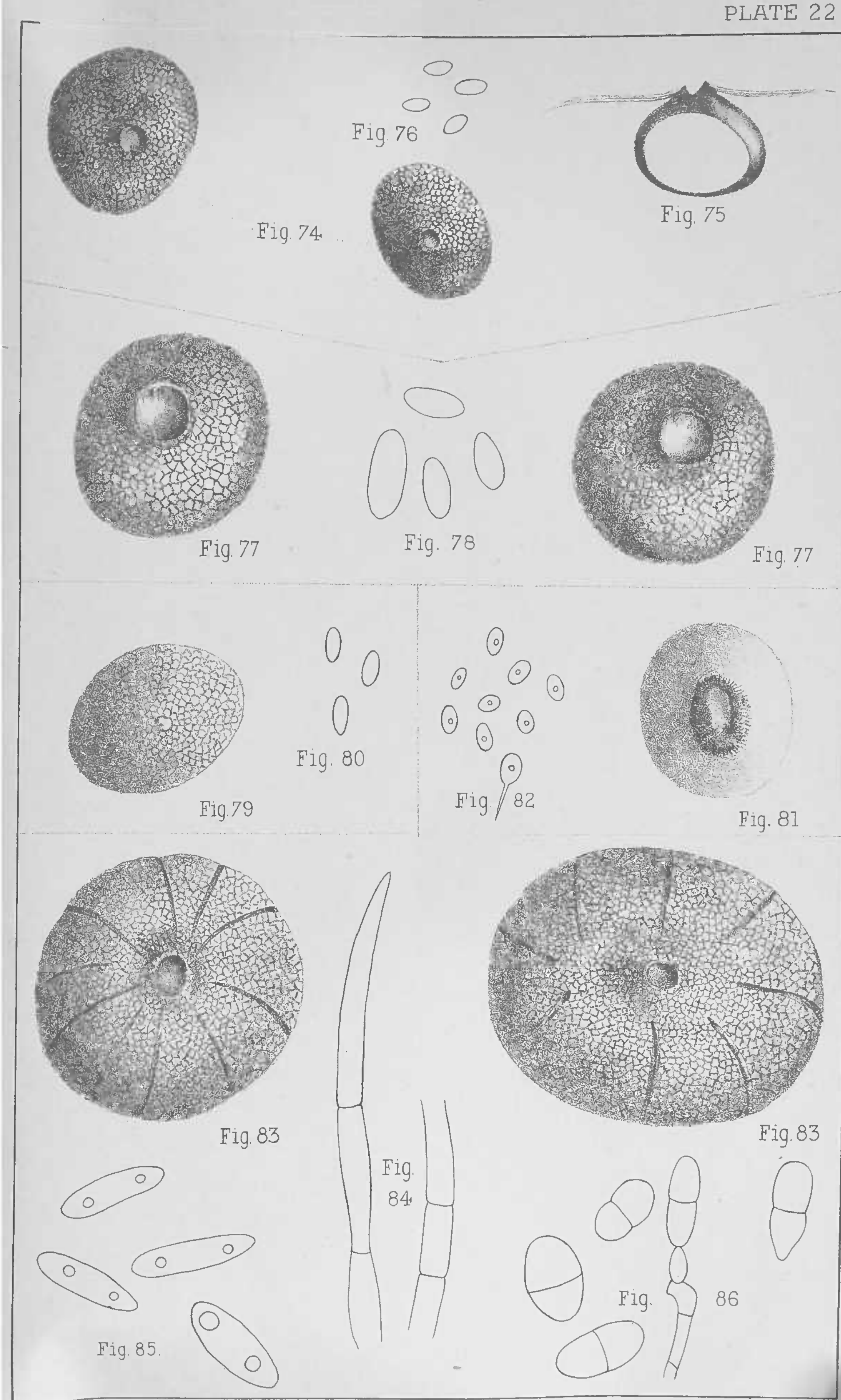
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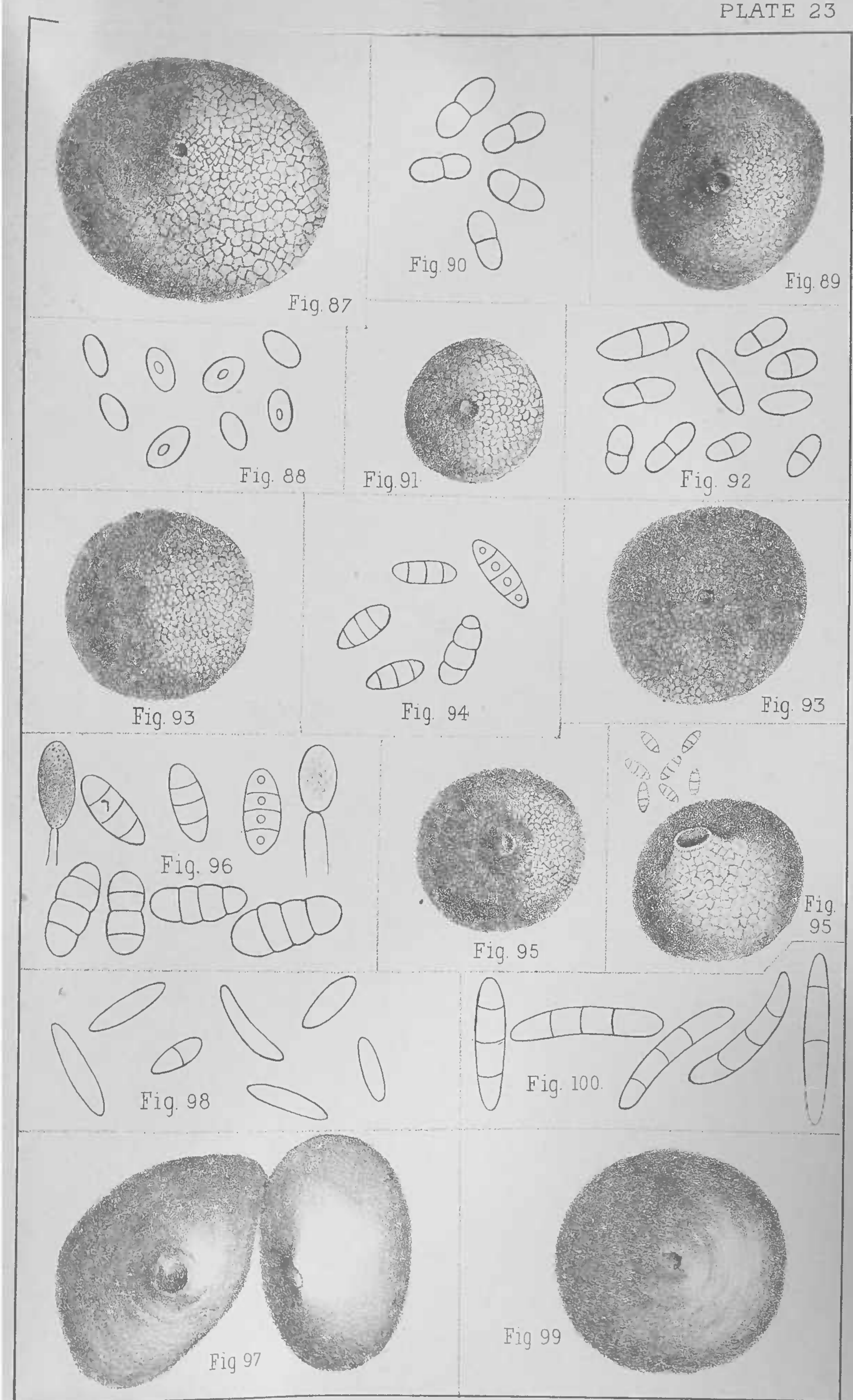
PLATE 23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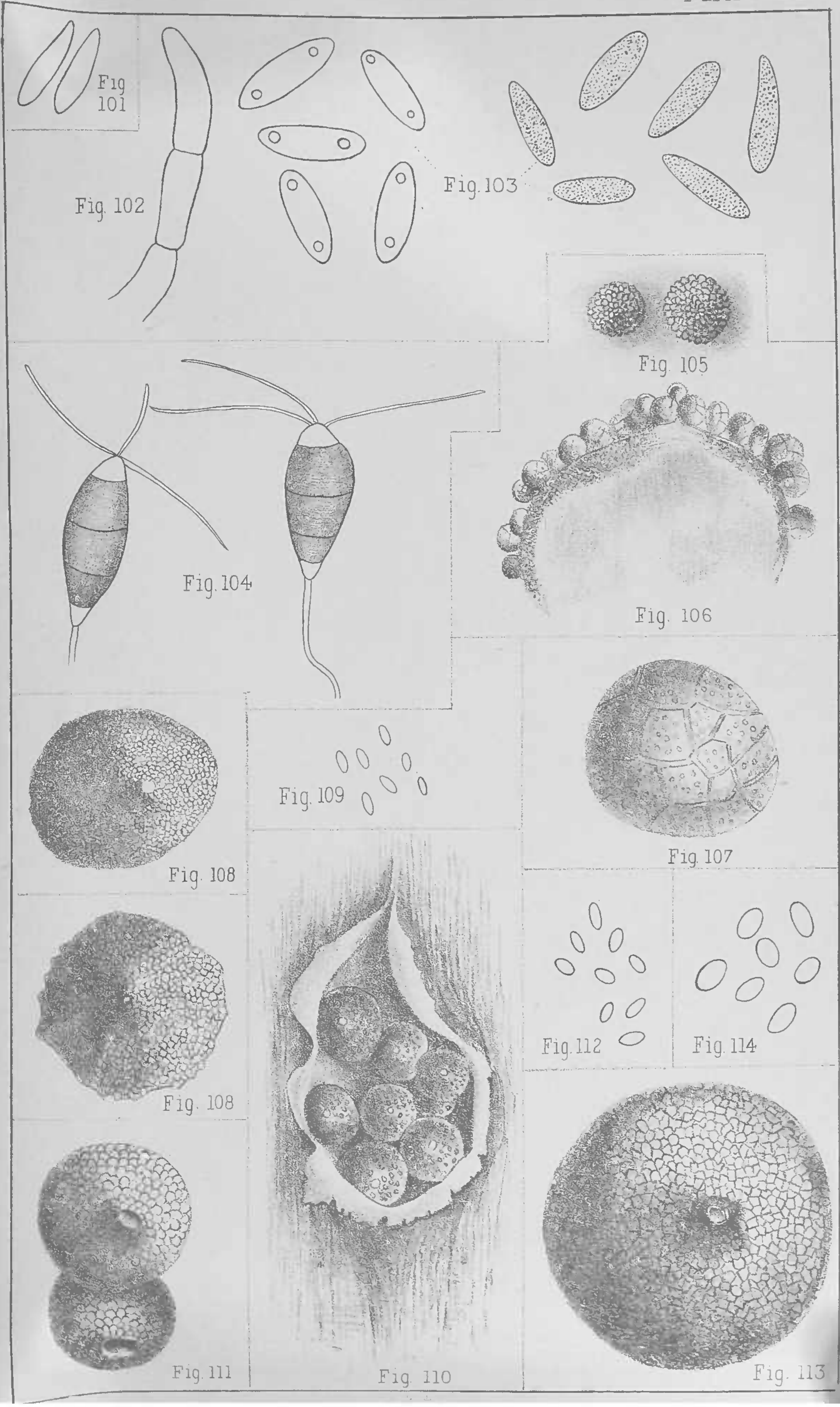
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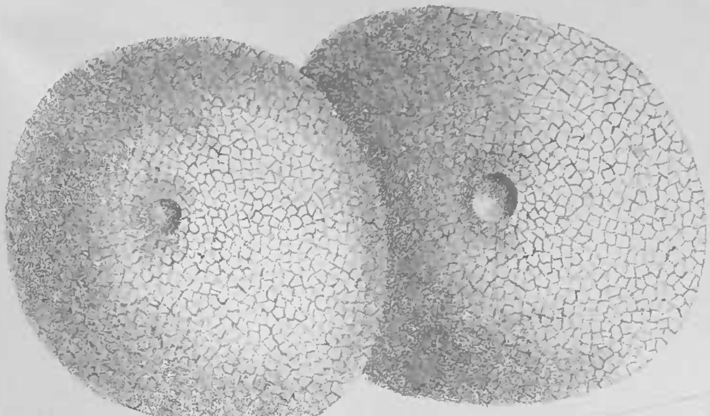

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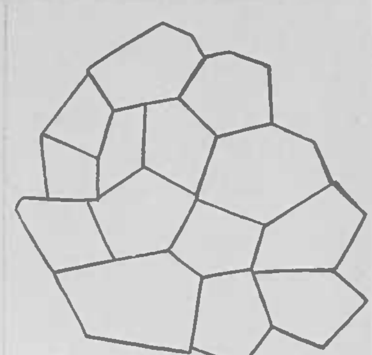

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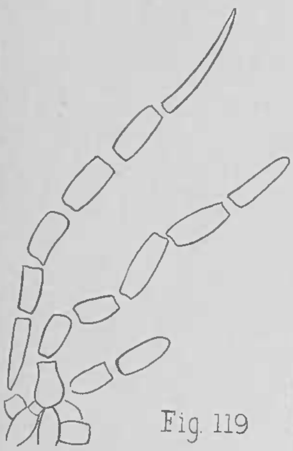

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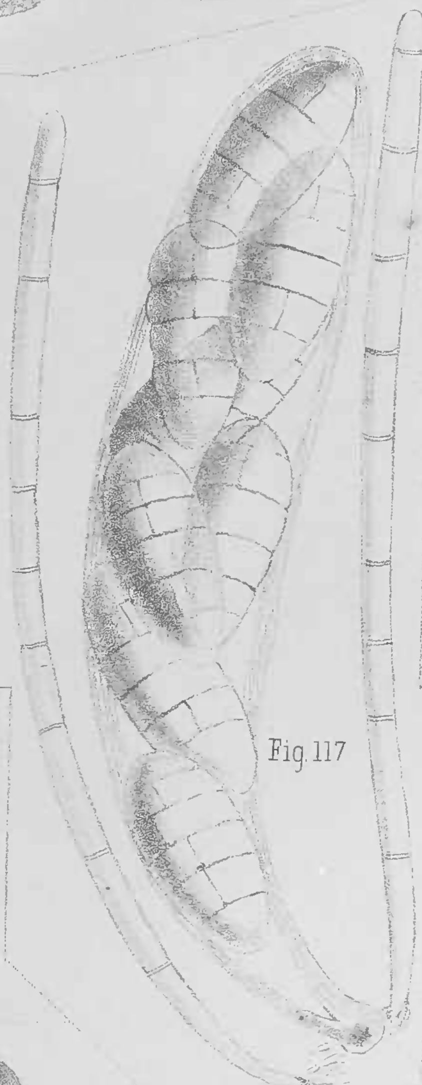

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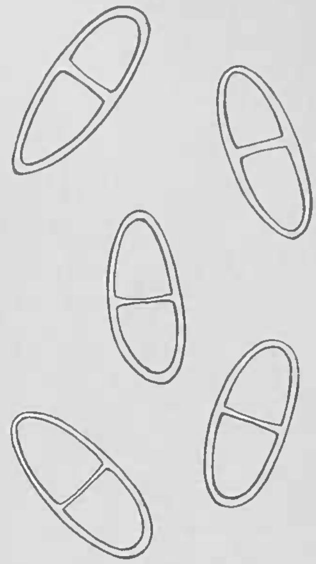
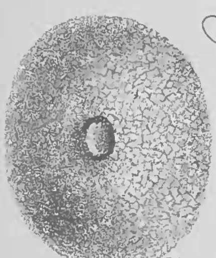


Fig. 118

Fig. 122



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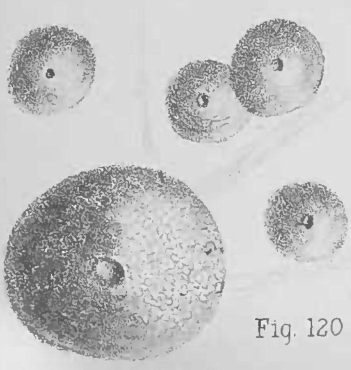

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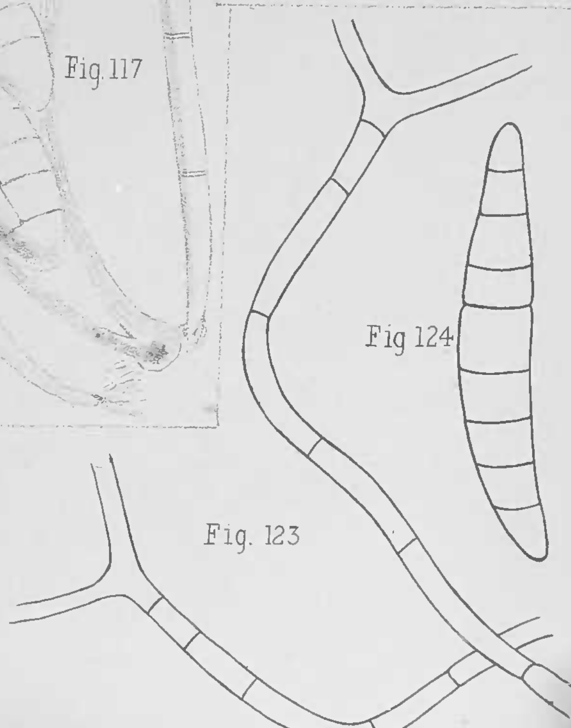
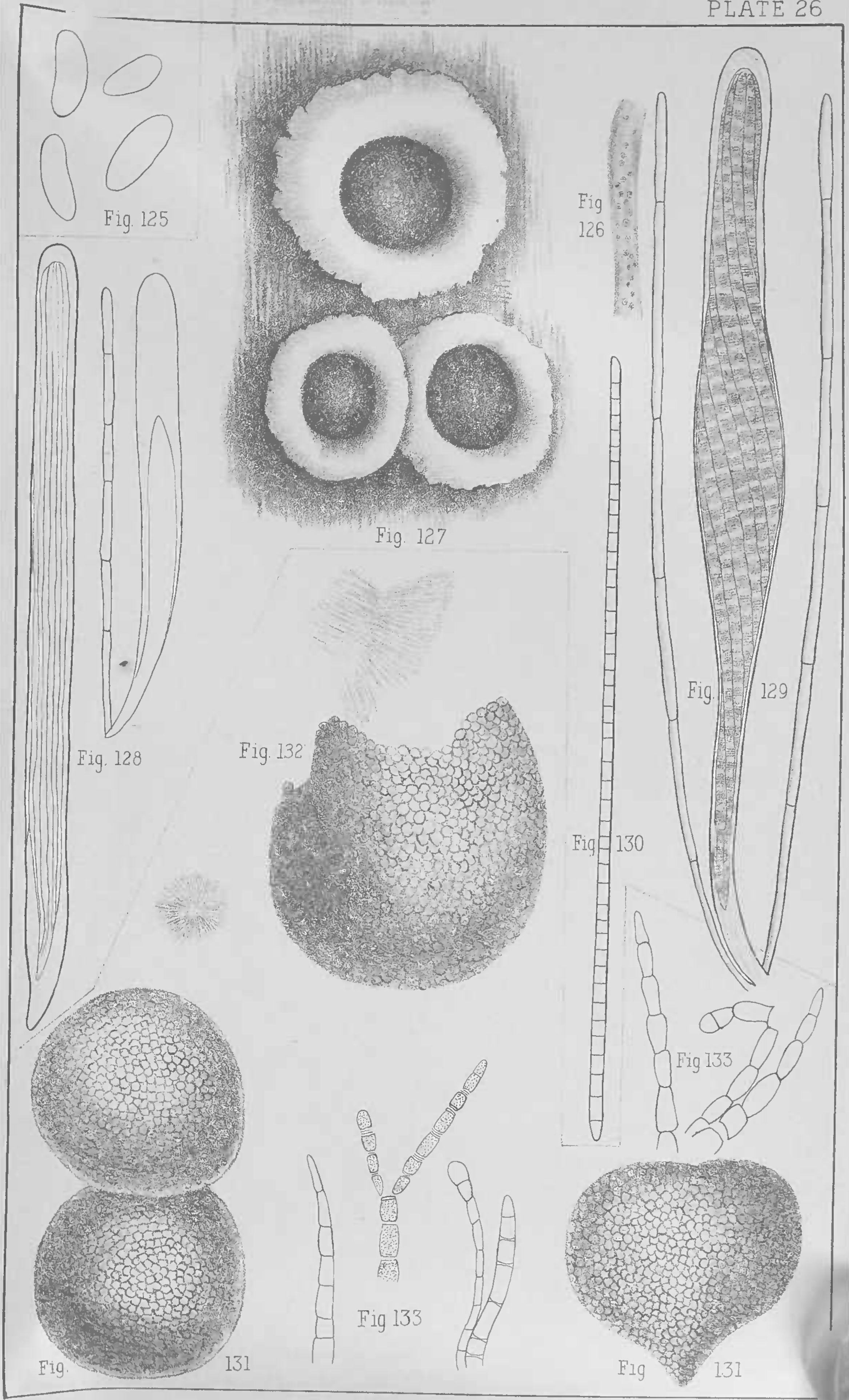


Fig. 124

Fig. 123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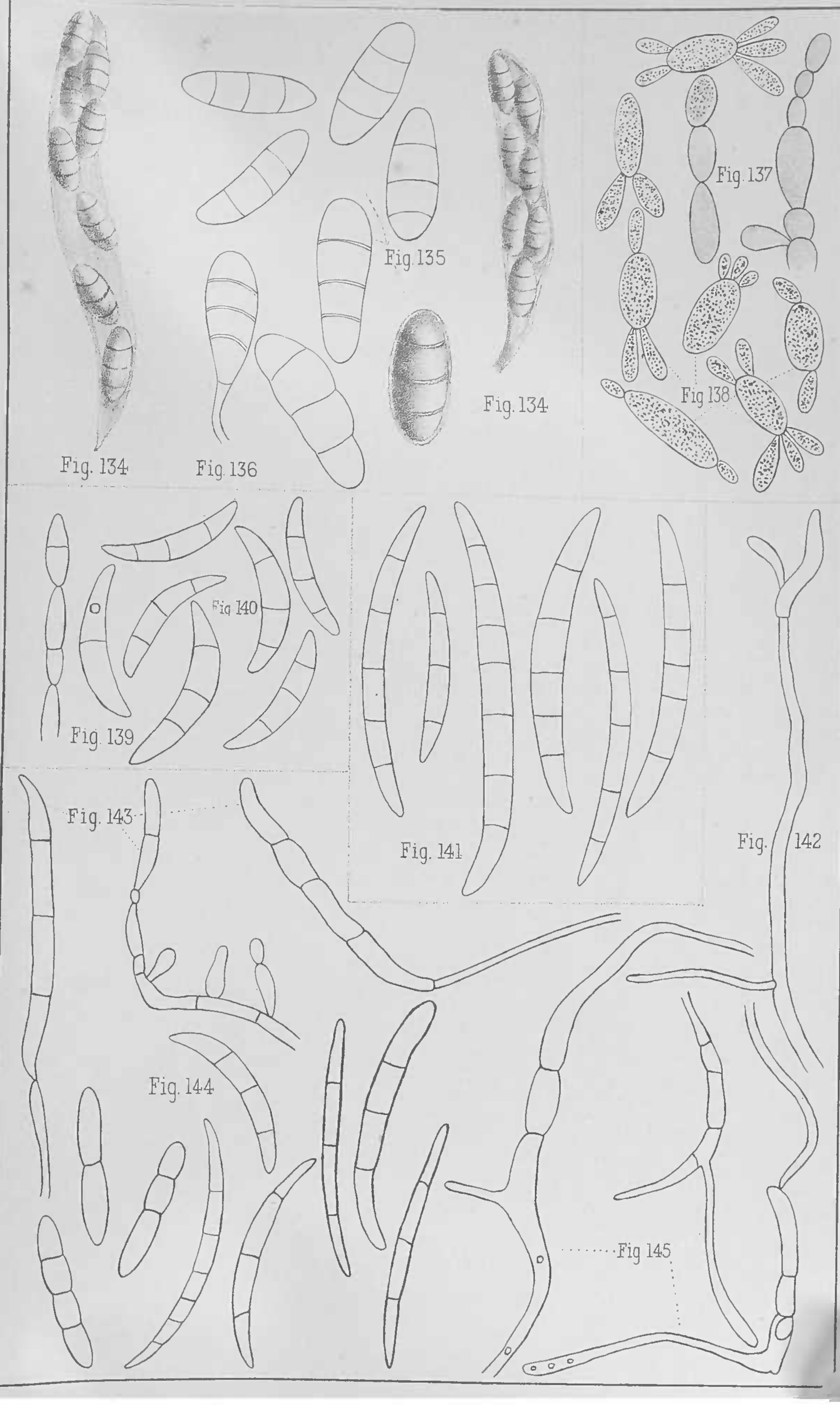
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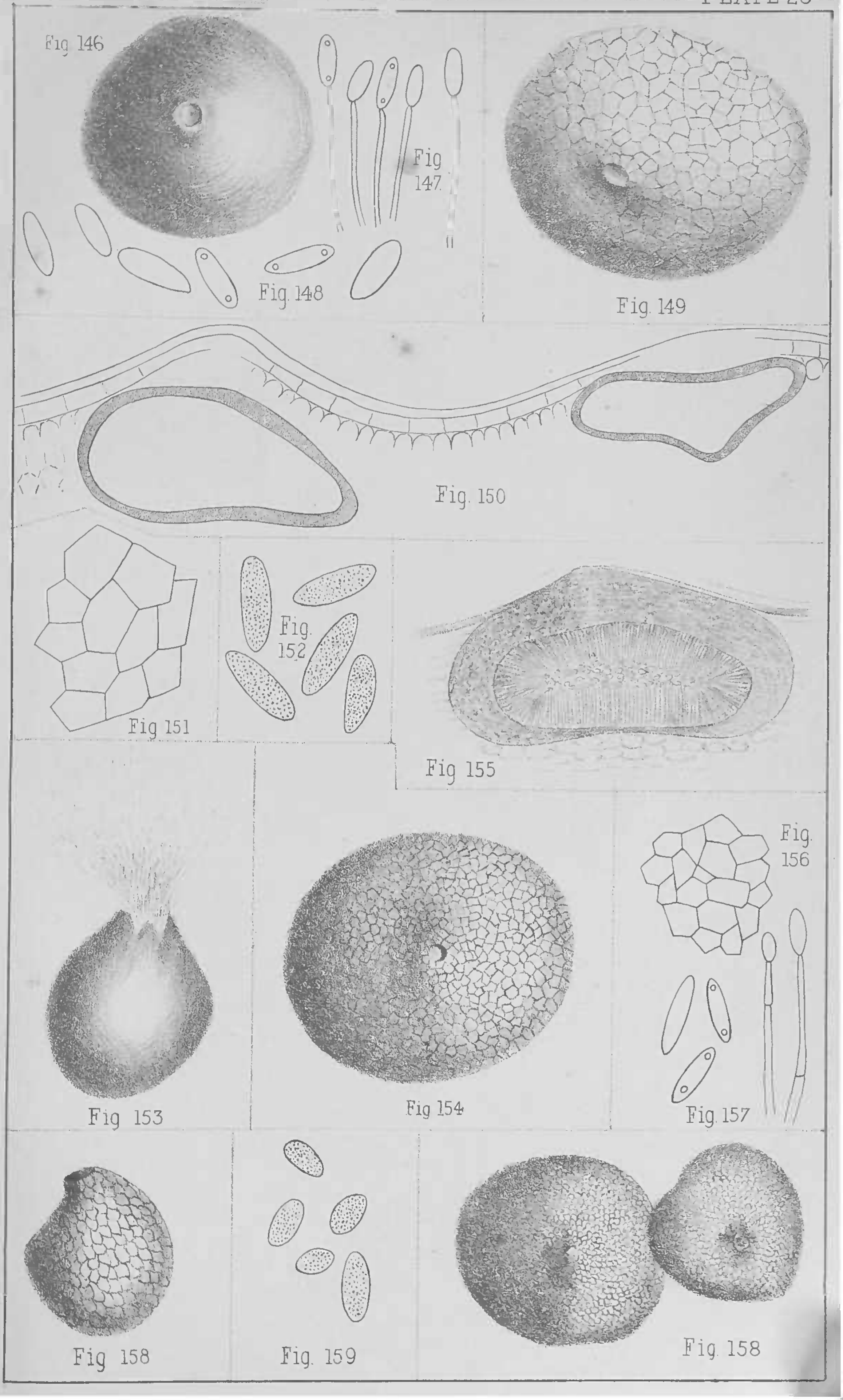
PLATE 28



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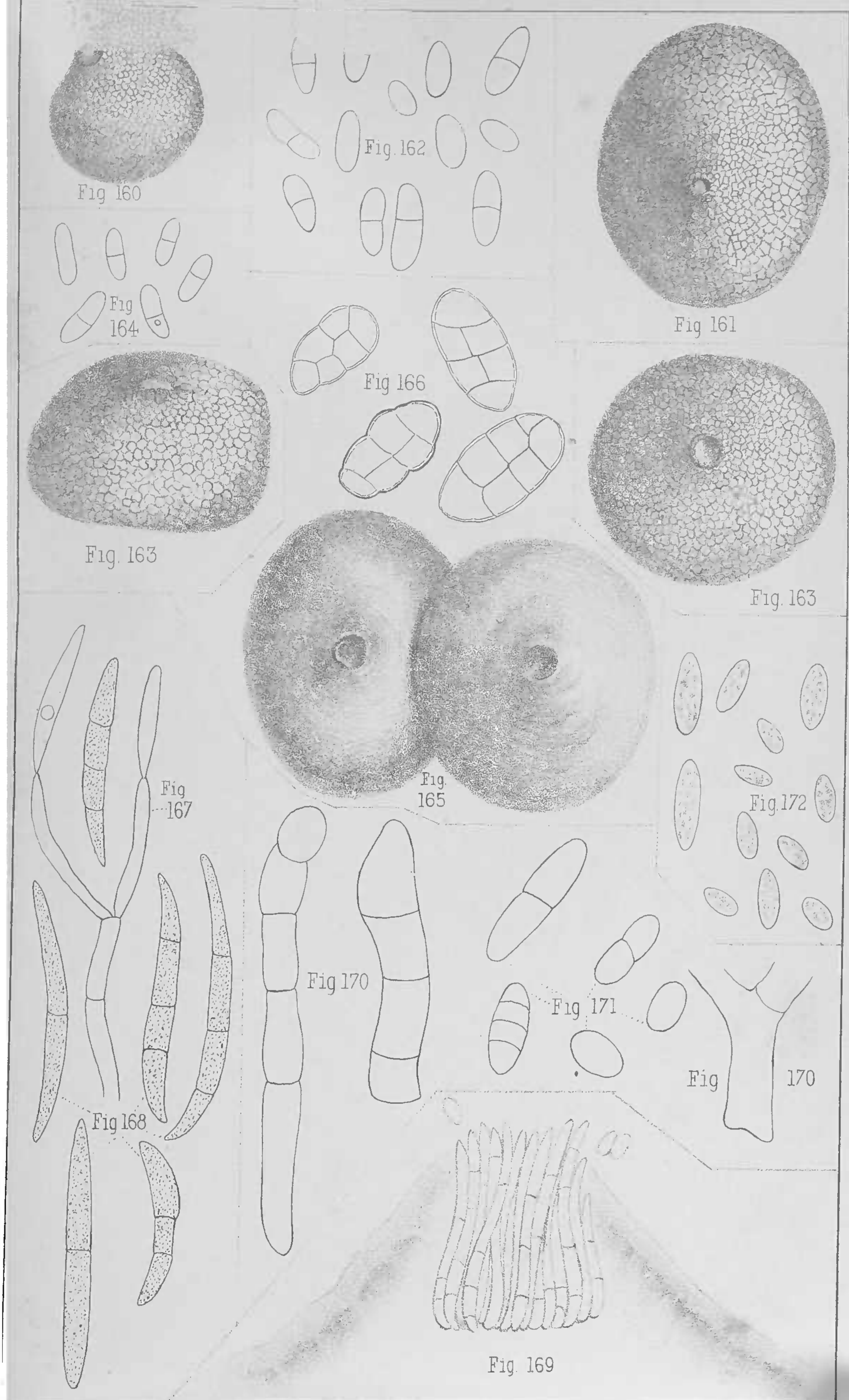
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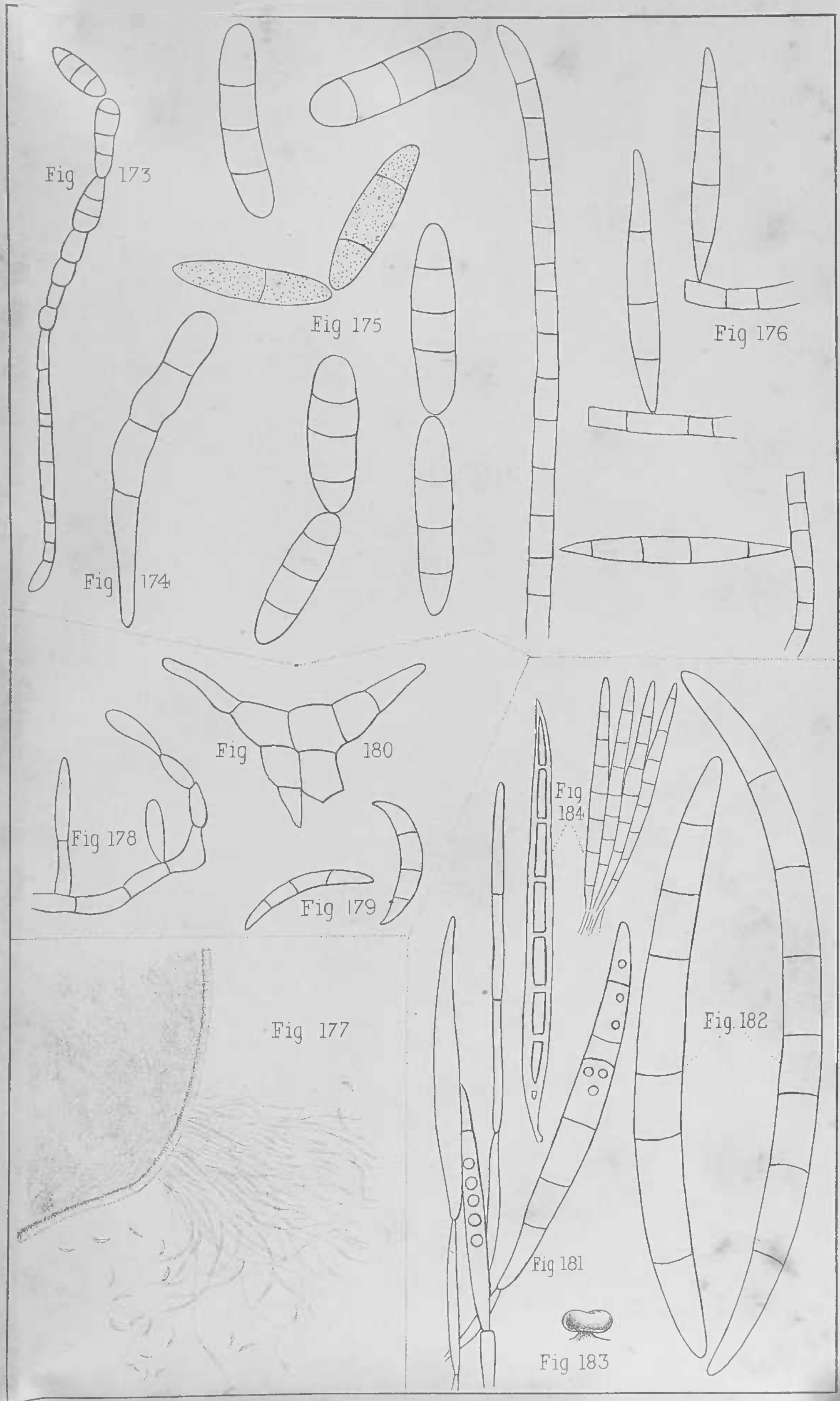
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PLATE XXXI.

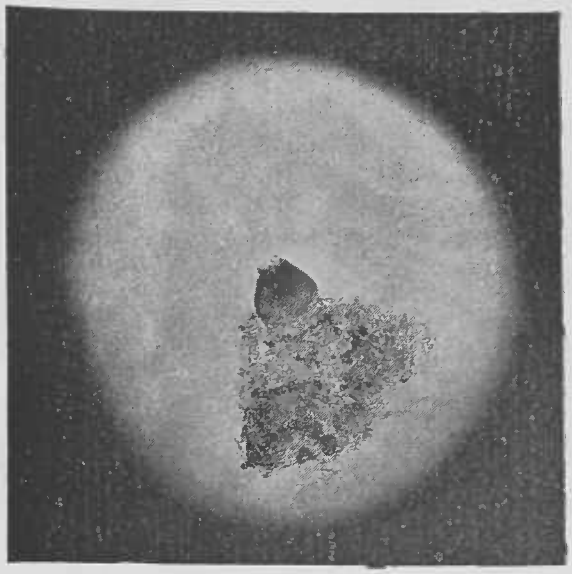

FIG. 185.

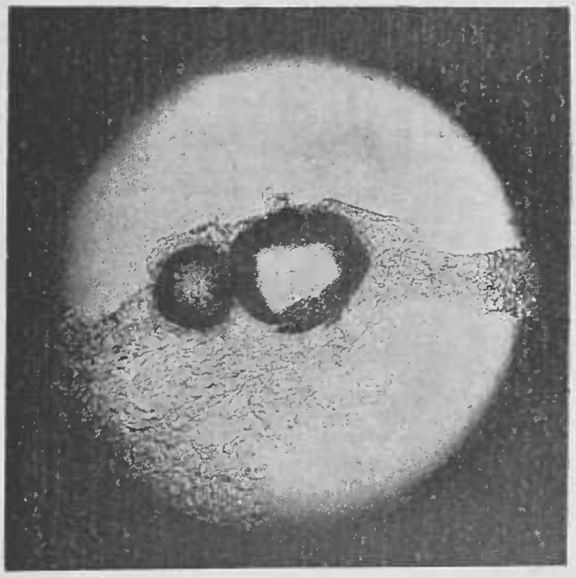

FIG. 186.