T H E S I S

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D I S E A S E S O F T H E A P P L E.

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Michigan Agricultural College, 1897.

THESIS

Diseases of the Apple.

This thesis is based upon a study of the botanical characteristics of some of the most destructive parasitic diseases of the apple. In one or two cases drawings were made from specimens previously prepared and mounted, but in all others, fresh material was available and was taken directly from diseased fruits in the laboratory. Besides giving the botanical characteristics of the diseases studied, a more general description and history of nearly all is given, including also remedies for their destruction. Owing to the fact that the work was done during the winter when there was no chance for observation as to time of appearance of diseases, rapidity of their development, destructiveness etc., the general descriptions are largely given as a result of investigations of reports of experiment stations, the United States Dpartment of Agriculture, the American Journal of Mycology and other reliable references.

Black Rot. (Sphaeropsis malorum, Berk.)

Plate I.

Apples are frequently found in autumn lying under the trees of the orchard, discolored by decay. Sometimes this discoloration is seen in them as early as September while they are yet hanging on the trees. It is the work of a fungus commonly called from its peculiar character, the Black Rot. The disease first manifests itself in the form of brown decayed spots on the side of the apple, usually starting near the stem, sometimes from the flower end. These spots gradually spread until the entire surface of the fruit is covered. After a time the brown color turns to black and then appear on the surface numerous little elevated pustules which in their formation rupture the skin. The tissue of the apple dries out and the apple becomes wrinkled.

The pustule is formed by a black, thick-walled body, which has pushed its way through the skin of the apple. In its interior are produced the spores of the fungus. Figure 1, represents a cross section of a pustule showing how it breaks through the epidermis. The spores are supported on short stalks which spring from all parts of the interior of the spore case. The ripe spores break away from this support and escape through the opening at the top as indicated in the figure. They are at first pale or colorless, but when mature, they become black or blackish-brown. They are oblong in shape and comparatively large being 30 micro-millimeters in their longest diameter. When sown in water in glass wells, the spores readily germinate. Figure 2 represents the manner of germination and appearance after being sown 48 hours. From one to three septate, hyaline germ-tubes are sent out from each spore which

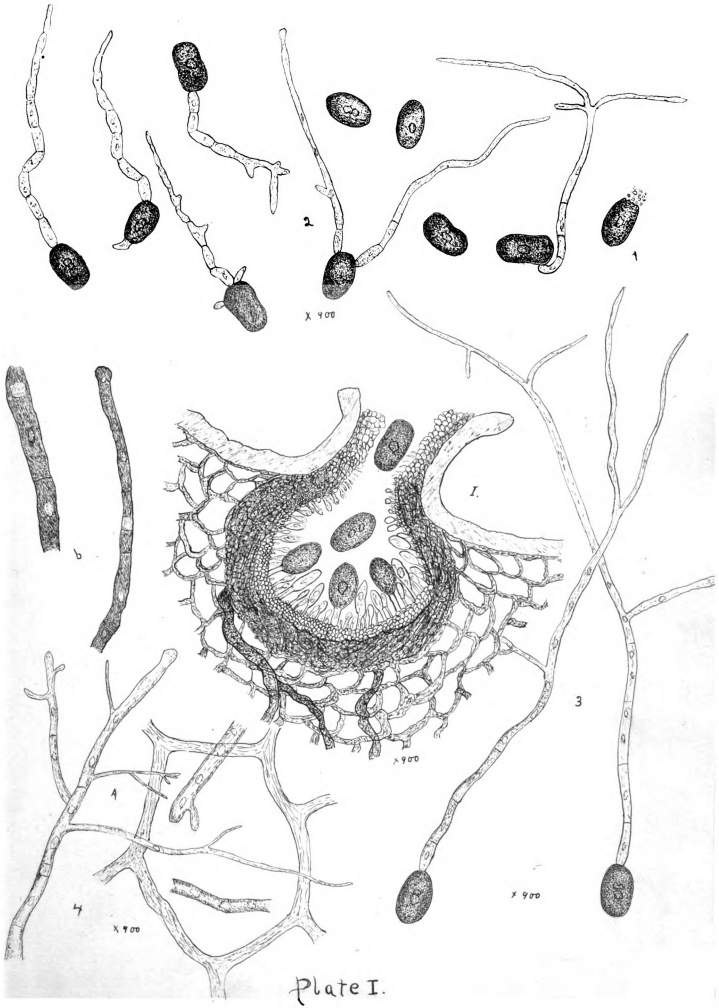


Plate I.

soon give rise to numerous branches. A few spores are shown which failed to germinate. (a) Fig. 2 represents a broken spore with granular contents. Spores of this fungus, as well as those of others grow much more rapidly and with greater vigor when sown in apple juice. In figure 3 spores grown in this way are shown. They were grown for the same length of time as those in figure 2.

Surrounding each of the fruiting bodies of the fungus and abundantly spreading everywhere in the diseased tissue of the affected apple is the mycelium of the fungus, nearly colorless and thin-walled in the tissue that is simply brown, but very dark and thick-walled in the parts immediately surrounding the pustules and in the black streaks and blotches conspicuous in the decayed parts. Figure 4 represents the manner of growth and appearance of the mycelium. a. shows the mycelium penetrating a cell of the host; b. shows the appearance of the older mycelium.

Black Rot of apples is common on both sides of the Atlantic, but no estimate of the losses occasioned by it has been made. The proper use of the sulphate of copper compounds has proven a succesful treatment.

Scab. (Fusicladium dendriticum).

Plate II.

The disease of the apple caused by the fungus parasite, Fusicladium dendriticum, has long been known to growers of this fruit as "Apple Scab." Of the two hundred or more fungi which mycologists have found on the apple tree or its fruit, this fungus is the best known and by far the most injurious. The distribution of the disease is almost co-extensive

with the cultivation of the fruit which it attacks, there being but few localities where it has not yet appeared. Since the disease is favored by a cool atmosphere, it is more prevalent in northern than in southern regions.

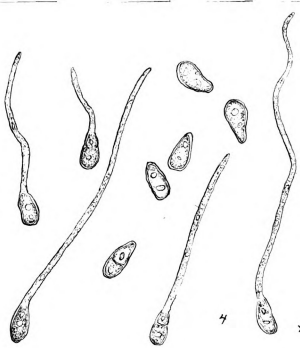
Leaves and young shoots are attacked by the scab as well as the fruit. On the leaves the first manifestations of the presence of the parasite is the appearance on the surface, of smoky, olive-green spots, rounded in outline. They are for the most part confined to the upper side of the leaf which often becomes much distorted through the unequal development of the two surfaces. The color of the older spots is nearly black and the surface somewhat velvety. Figure 1 shows the appearance of an affected leaf. The growth of the young shoots is often seriously checked through the direct action of this fungus upon them, and when the foliage of a tree is much affected its nutrition must be seriously impaired. The development of the spots on the fruit is quite similar to that which takes place on the foliage. As they increase in size, the ruptured cuticle appears as a light colored ring around the borders, and frequently flakes of cuticle adhere to their surfaces and impart to them a more or less grayish appearance. Figure 2 represents an affected apple.

The growth of the fungus does not extend into the deeper tissues, but is limited between the cuticle and epidermis proper. The cells composing the latter are turned brown or are even destroyed by the parasite, as are also occasionally a few of the underlying pulp cells. After the fungus has grown for some time beneath the cuticle, it breaks through this covering and becomes exposed to the air. It is then ready

to produce spores. The spores are born on short upright stalks as shown in figure 3. They are oval or pear-shaped and dark olive-brown in color, like the filaments which support them. They are produced in great numbers throughout the season of growth and to someextent on stored fruit, and are ready to germinate as soon as mature. Figure 4 shows the manner in which the germ-tubes are pushed out in germination. The drawings were made 24 hours after the spores were placed in water. Figure 5 shows a number of germ-tubes, 24 hours later, or at the end of 48 hours from the time of sowing the spores. One of these germ-tubes from a spore resting upon the surface of an apple penetrates the cuticle, between which and the epidermis further growth is continued, resulting finally in the rupture of the cuticle and the production of a new crop of spores.

The fungus appears to be retarded in its developement by the heat of summer. Its most rapid growth takes place during moist, cool weather such as usually prevails during the early months of spring and autumn. The parasite doubtless retains its vitality during the winter, both on the twigs in the orchard and on the fruit which it infests. From the former it doubtless spreads to the new growths of the following season and thus the pest is perpetuated from year to year.

Some varieties of apples are more liable to be affected with scab than others and in selecting varieties for culture the fruit-grower should take this fact into consideration. Direct treatment by the use of fungicides is the only method by which the disease may be overcome, and for this purpose there is nothing perhaps which proves more effective thanBordeaux mixture. The trees should first be sprayed in early spring



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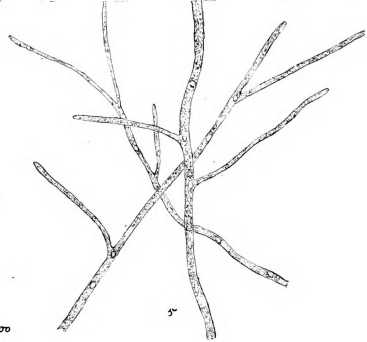

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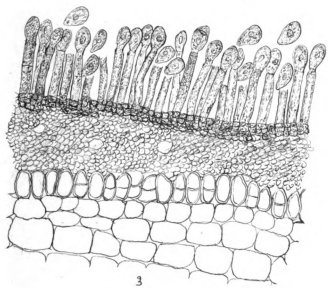

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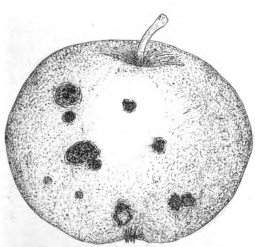

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Plate II

before the buds have commenced to expand. During the growing season, there should be at least three treatments, one just before blossoming, one when the fruit is set, and one when the fruit is half grown. For the first spraying a much stronger solution may be used than for later treatments.

Pear Blight. (Micrococcus amylovorus, Burrill).

Plate II.

This bacteria is the cause of "blight" in plants, especially of the pear tree (fire blight) and of the apple tree (twig blight and sun scald.) The organism gains entrance to the living tissues through wounds or punctures and produces butyric fermentation of the starch stored in the cells (?). The disease is transmissable by artificial inoculation.

The cel s, represented in figure 6, are oval, single or united in pairs, rarely in fours, never in elongated chains, imbedded in an abundant mucilage which is very soluble in water; movements oscillatory; length of a septate cell .00004 to .000056 in.; width, .000028. Burrill.

Extract from report of J.C. Arthur. (N.Y.Agrl.Exp.Station).
The disease is readily communicable to suitable healthy branches, by introducing a drop of watery solution of a diseased part or of the gummy exudation. Experiment has proven that juices accompanying the blight will not induce the disease in any form when freed from the blight bacteria. The bacteria gains entrance to the interior through the delicate surface tissues of the expanding bud. The trees are usually attacked in spring, and the disease passes through a period of incubation of a month

or more before becoming sufficiently conspicuous to attract attention; however, in exceptional cases where the shoots still continue to push out vigourously, or throughthe agency of insects, the attack is later in the season, possibly as late as midsummer. Careful experiments have shown that the danger of spreading the disease with the pruning knife is not great enough to warrant the extra trouble of keeping the blade disinfected. Germs will grow in dead organic matter outside the tree. So long as thisfact was not recognized, the mode of transmission of the disease remained obscure. A marsh or any wet land rich in organic matter may sustain the disease, presumably for years, and aided by favorable winds and other conditions, be the origin of an epidemic. Direct infection from a neighboring tree or branch, even though the diseased branches may touch the healthy ones, rarely, if ever occurs; the bacteria are imprisoned by bark, or escape in viscid substance that dries into a hard gum, and hence do not pass directly from the tree into the air; lastly it has been shown that the germs enter the tree in early spring when but little living pear blight is to be met with. The substance which is obtained by the action of the blight bacteria on the starch, unlignified cell-walls and other substances of the plant tissue, is a very viscid, creamy matter, soluble in water, and drying to a hard gum on exposure to the air. This seems to be one of the viscous fermentations, a class whose physiology and chemistry has been but little studied, and the investigation of which is beset with unusual difficulties.

Division of Vegetable Pathology, U.S.Department of Agriculture,

by M.B.Waite.(Extract).

Pear blight not unfrequently plays sad havoc with the blossoms,

especially in the South. The disease spreads from flower to flower by means of insects. It multiplies in the nectar, and the insect visitors that dip their mouth parts in the infected flowers carry the infection to those which they afterwards visit. In this way, whole orchards of LeConte and Kieffer pears, especially the latter, have had their flowers destroyed.

Bitter Rot. (Gleosporium fructigenum, Berk?)

Plate III.

Bitter or ripe rot is caused by a fungus growth which confines itself to the fruit and has no other host plant than the apple. It occurs only after the fruit is quite well grown, usually when approaching maturity, but continues to develop in the stored fruit. Infection arises largely from fruit left upon the ground and the refuse from the pit or storage cellar.

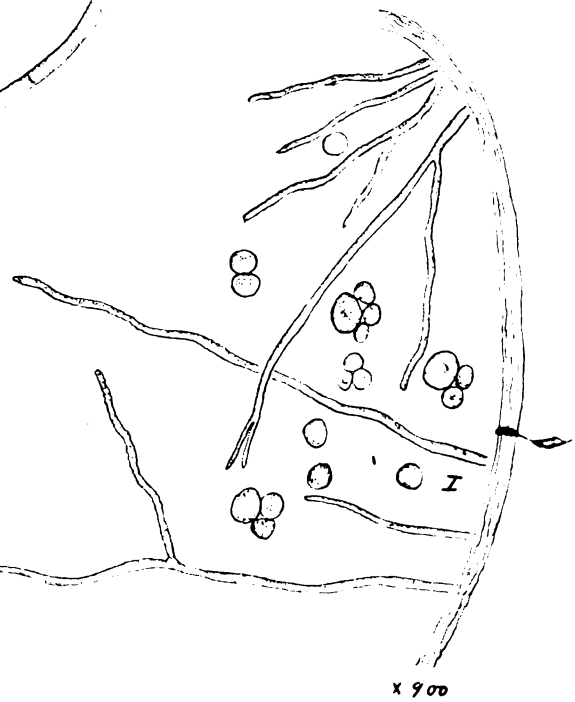
The rot may be identified by external appearances. Brownish spots first appear on any part of the surface; as these gradually enlarge their shape becomes more or less circular and their borders somewhat sharply defined. Sometimes the spots coalesce, and the entire apple is soon affected. Toward the center of the diseased spot there is usually a very dark, frequently almost black, discoloration. Usually, by the time the diseased spot has reached the size of a silver half dollar, the fungus begins to mature spores. These are born in small pustules which occur thickly over the diseased area and pushes the epidermis upward, finally erupting it in numerous small openings, at which the spores escape. These spores may under proper conditions, spread the disease

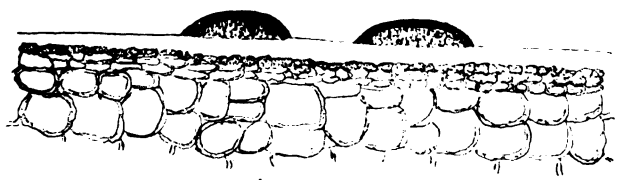
rapidly. (The manner of spore formation is not shown becaus we have been unable to obtain fruiting specimens).

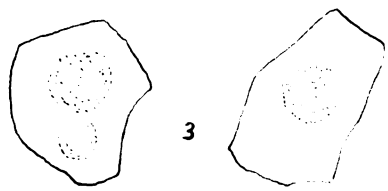
The mycelium consists of slender threads, which push their way through the tissue of the plant and destroy the parts with which they come in contact. These threads vary much in size and color. Upon the tips of closely compacted threads spores are born. These are colorless or nearly so, cylindrical in shape, rounded at each end and occasionaly somewhat curved. Each thread develops a single spore, but the former are so thickly compacted that an immense number of the latter are developed in each pustule. Figure 1 shows a portion of a fruit cell into which the mycelium has grown. Starch granules are found in abundance by the action of the mycelium and are found in connection with it as represented in the figure. Figure 2 represents a spore growth found in connection with a prepared slide of the rot. It is quite probable, however, that it is not a growth of some form of this fungus, but of spores of some other disease, which accidentally gained access while the slide was in preparation.

The fungus has been known on the apple for a long time, Berkeley's first description of it dating back to 1856. It has of late years proved very destructive in certain localities especially in the South and Southwest.

Since a diseased fruit may affect the healthy ones that lie in contact with it, it is of great importance to carefully cull all fruit among which the presence of the disease is suspected. The disease can be almost wholly avoided by the use of fungicides, potassium sulphide (one-half ounce to a gallon of water) and the ammoniacal copper carbonate.







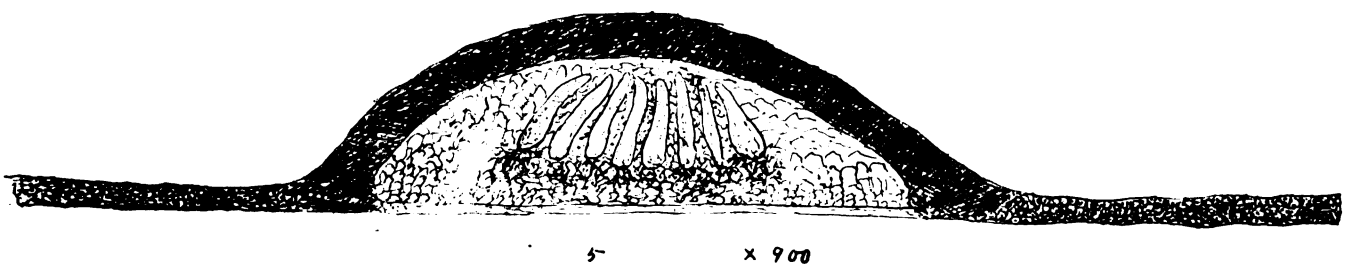


Plate III

Apple Speck. (Leptothyrium pomi.)

This disease affects the skin of the apple by covering it with patches of minute black spots as represented in figure 3. Since the disease does not extend below the epidermis as s own by cross sections of two specks in figure 4, the internal tissues are not impaired as is the case in most other fungus diseases. However, the fruit is rendered unnattractive in appearance and seriously injured so far as market value is concerned.

Figure 5 is a cross section of a perithecium drawn on a large scale. In the interior, a number of asci are represented. These asci are enlarged terminal cells containing free spores. When the perithecium is fully developed it bursts at the upper extremity and the spores escape.

The following is translated from Saccardo:-

"Perithecium almost black, in the shape of a flattened hemisphere, slightly depressed in the center, glossy". Mature asci and spores not seen in my specimens. Found on skin of the apple.

The drawings were made from diseased fruits of wild apples growing in the Arboretum.

I know of no treatment having been recommended.

Powdery Mildew. (Podosphaera oxycanthae (D.C.) D By).

Plate IV.

This species belongs to the family known as Erysiphae, all of which are known as mildews. The parasite is entirely superficial except for haustoria which barely penetrate the epidermal cells. The perithecium has dichitomously forked appendages as shown in figure 1, a; b shows an appendage much enlarged; c shows an ascus which contains eight spores.

The disease is especially destructive to seedlings in the nursery throughout the growing season, making it impossible to bud them with any degree of success. It usually appears late in September, when the principle growth has been made, and seldom if ever spreads to vigourously growing stock, even when in close proximity to diseased seedlings. The disease attacks the young tips of shoots, often stunting the growth of the seedlings and preventing them from obtaining a suitable size the first season.

The ammoniacal solution has proved the cheapest and most effective remedy for the disease, and five sprayings seem to be required. The first application should be made just as the leaves start in the spring. At least three other sprayings should be made at equal intervals between the time of the first treatment and the time for budding. Ten or twelve days after budding the last spraying should be made.

Plate IV.

Apple Rust and Cedar Apples.

(Gymnosporangium macropus and Roestelia pirata.)

Plate IV.

A part of the life of this fungus is spent upon the Red Cedar, and wherever the Red Cedar grows, the apple rust is likely to be found. The attacks of the fungus first appear during the latter part of May or early in June in the form of numerous bright yellowish-orange spots on the leaves. At these points of discoloration the leaf tissues are thickened as shown in a cross section of a leaf, a Figure 4. If after a few days, the spots be examined closely, many minute nearly black points may be seen on the upper surface. These are the spermogonia,- hollow bodies bearing at their ends very minute [illegible] termed spermatia. The exact office or function of these [illegible] in this case is not well known. Late in the season [illegible] cups each with a lacerated or fringed border, appear. Within [illegible], [illegible] powdery substance, the spores of the Roestelia, is found. Figure 2 b. represents one of these cluster-cups showing the manner in which they burst through the surface of the leaf and how the spores are born. A pseudoperidium, a section of which is represented in c. forms the outer investing case of the aecidiospores. It is composed of sterile cells.

The cedar apple appears on the branches of the cedar as a round brown or yellow jelly-like mass, swelling out to greatly increased size after a rain, developing a number of sprangling appendages of similar substance, radiating in all directions from its surface. Its growth, however, does not begin in the spring, but in the summer or fall before, when by close observation, it might be seen as a small brown sphere.

This may swell to a considerable size before winter, but not until spring is it conspicuous enough to attract attention. In the spring it grows to any diameter not exceeding an inch to an inch and a half, and small protrusions of a brighter brown are seen at different points on the surface. These may become elongated. The whole ball swells, but the protrusions swell most, and become long, sprangling arms of a bright yellow jelly. A microscopical examination shows imbedded in the jelly numerous spores, each divided across the middle by a partition and attached to a long, slender stalk, of which only a very small portion is shown in the figure. The spores- figure 3- now germinate, and each cell produces one or more short filaments, from which arise spore-like bodies called sporidia.

The fruit when attacked by the rust is rendered worthless, and the ripening of the fruit is occasionally prevented on account of the early destruction of the foliage by the fungus. Trees are sometimes partially defoliated by the first of August by this cause.

The rust fungi are the most difficult to combat; their habit of passing certain periods of their lives on different host plants and of occasionally becoming perennial in the plants they attack, will account for this.

I. Where this fungus thrives remove from near the orchard all Red cedars.

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

III. In localities where the rust occurs, spray all young trees and those which have not become too seriously diseased with Bordeaux mixture.

making the first application as soon as the leaves are fully formed. The spores are carried a great distance. Apple trees a mile or more from the cedar trees are sometimes affected.

Crustaceous Mold. (Penicillium glaucum, Grey.)

Soft decaying spots, of a peculiar brown color often make their appearance on apples stored in a warm room. Frequently a species of mold develops on these spots. At first minute white tufts appear, but they soon acquire a pale bluish-green color. These tufts are usually about as large as the head of a pin. Figure 1 represents a tuft magnified with a low power. These are the hyphae sent up by the mycelium on which spores are born.

The mycelium of the fungus are slender fungoid filaments running in every direction. They are the immediate cause of the rot. Figure 2 is a representation of a part of one of these threads, and figure 3 is a cell of the host, through which the mycelium has passed. When the mycelium comes to the surface, fruiting stems are sent up, one of which is represented in figure 4. These stems are delicate, jointed threads which give out near the top, one or more pairs of short opposite branches which are themselves forked. Each alternate branchlet bears at its tip a string of spores. The spores are globular, and range from twelve to twenty one hundred-thousandths of an inch in diameter. They grow very readily in water, sending out long, branching, hyaline threads, as shown in figure5 which represents a growth of 72 hours. After 120 hours some of the spores gave rise to fruiting forms as shown in figure 6.

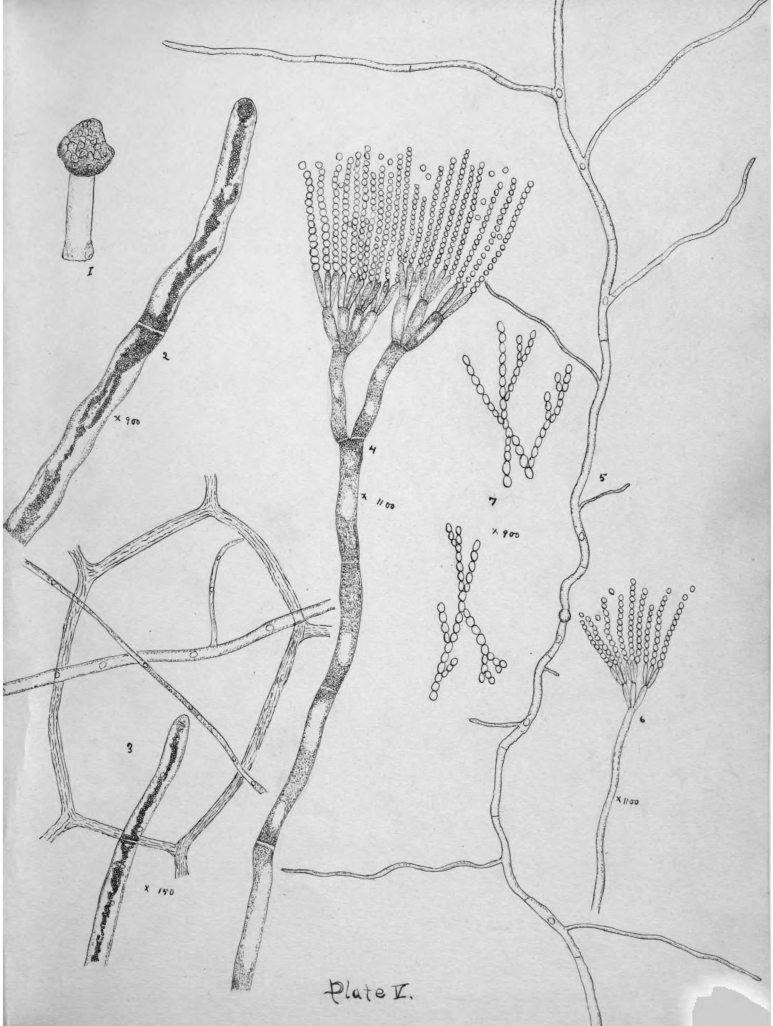


Plate V.

Yeast is found in abundance in connection with the penicelia (figure 7) and is in fact nothing more than a peculiar condition of the Penicelium glaucum, which is capable of almost endless propogation without even bearing perfect fruit. The penicelium is the common blue mold on all sorts of decaying bodies.

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