

**A New Species of Hymenomycetous
Fungus Injurious to the
Mulberry Tree.**

by

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With Plates XXIV—XXVII.

In Japan the mulberry tree has been widely cultivated, from time immemorial, for rearing silkworms. Although the methods of its culture have much improved, yet its diseases, especially those caused by fungus parasites, have been overlooked even by skilful cultivators. The chief reason for general neglect regarding these points is the want of accurate knowledge of the nature and biology of fungi. One of the most serious diseases of this kind is that which is known under the name of "Mompabyō."* This disease has produced much distress at various intervals for about eight years, in the experimental farm of the Agricultural College at Komaba, Tōkyō. Some distinguished biologists and agriculturists have investigated its nature, and stated that it was due to the ravages of a sterile mycelial stage of a fungus of some other form, but its true nature has never yet been fully explained. I have lately had the good opportunity to study this disease under the direction of Prof. R. Yatabe. The object of this paper is to deal with one or two of the unsettled questions regarding it, namely, the morphology of the perfect condition of the fungus which causes the disease, and its systematic position.

* *Mompa*, a kind of nappy cotton-cloth; *byō*, disease.

Towards the end of last year, I obtained specimens of mulberry trees attacked by the disease, but unfortunately the specimens were so far advanced in decomposition that the course of the mycelium of the fungus in its relation to the internal tissues of its host was not clearly definable, and also the fructification of the fungus could not be found. Since then I have examined many other specimens, up to the beginning of April of this year, and at length found the perfectly developed condition of the fungus. Its specific characters are as follows:—Pileus sessile, resupinate, somewhat orbicular or oblong, often irregularly lobed, 5–10 cm. across, 2–4 mm. thick, at first velvety and membranaceous, then subcoriaceous, somewhat convex, incrustate, purplish brown, at length albo-pruinose; hymenium white; basidia curved, 1–3-septate, tetraspored; sterigmata elongated; spores ovoid, curved, hyaline, 10–12 μ . long, 5–7 μ . broad.

By the above characters, especially by its peculiar form of basidia and by its nature, I consider that this fungus belongs to the genus *Helicobasidium* in the family *Thelephoræ* of the *Hymenomycetes*. It has much resemblance in its characters and habit to many species of its allied genera; but it can be distinguished from *Thelephora* and *Corticeum* chiefly by having an intermediate stratum in the pileus, and from *Stereum* by having a usually superior hymenium. Of the species of the genus *Helicobasidium* but few are known; in Saccardo's *Sylloge Fungorum** only two species, *H. purpureum* (Tul.) Pat. and *H. cirratum* Pat. et Gail., are given. By comparing my description of the fungus with that of the above named species, it can be distinguished from the former chiefly by the colour of the pileus and the number of spores borne on a basidium, and, from the latter, by the diameter of the pileus, the number of spores borne on a basidium,

* Vol. VI. p. 666.

and their size. An allied fungus on the mulberry tree in South Carolina, North America, was described by Prof. Berkely under the name of *Stereum moricolum*; and two other species of *Stereum*, viz. *S. subcruentatum* B. et C. and *S. contrarium* Berk., are given in Saccardo's *Sylloge*.* These are Japanese species, but unfortunately I have never yet found them. They must, however, be very distinct from my species. For these reasons I venture to call it *Helicobasidium Momp*† from the well known Japanese name of the disease.

The fungus at first attacks the root of a living tree, and the diseased tree shows external symptoms of the disease on portions above ground: usually the growth of shoots is arrested, the newly developed leaves become gradually smaller and at length die off; then the lower part of the shoots begins to die, though the bark higher up may preserve its normal appearance. It takes a tree one or two months to reach this state, after it has first shown the external symptoms of the disease.

On uprooting a young mulberry tree badly attacked by the fungus, the roots are found to be killed from below upwards, and present the appearance represented in Plate XXIV, Fig. 1. The tree figured there is three years old; the roots marked *a* have grown three years, and those marked *b* and *c* are of this year. The portions marked *a'* are dead roots, whose bark was already severely injured and so loose that it was separated by the act of uprooting. As these dead roots were of no use to the tree, it produced the new roots *b* to absorb nourishment from the soil. But the newly formed roots were also injured as the disease advanced, and became unfit to perform their function; and at length another crop of newer roots *c* was produced higher up, by means of which the tree was enabled to

* Vol. IV. pp. 507 and 579.

† See p. 193.

sustain its life. In the state just described no fructification of the fungus is yet observable, although its subterraneous vegetative mycelia are actively growing.

After the fungus has been growing in this manner for some time, flat irregular disks of mycelia begin to form under certain circumstances on the aerial portion of the tree at the bases of the shoots. These disks are the first stages of the pileus. The successive stages of growth of the pileus are shown in Plate XXIV, Figs. 2, 3, and 4. It first appears as a thin effused mass of mycelia of a dark purplish brown colour, having a paler margin of definite outline, and presenting a smooth velvety appearance (PL. XXIV, Fig. 2, *a*). It surrounds the basal part of the shoots of the diseased tree to a height of 15 cm. or more, sometimes leaving here and there small narrow portions uncovered. It often encloses in its embrace some extraneous matter, such as decayed leaves, branches, and the like, together with particles of soil. As it gradually develops, it forms generally an irregular roundish flat disk, one part of which stands out at right angles from the surface of the shoot, while the other remaining part is firmly attached to it. The projecting part of the pileus then expands laterally either on one side of the shoot or on both sides; and as the shoot is usually bent horizontally at the base, the pileus becomes also horizontally expanded. The hymenium is produced on the free surface of the pileus, on the upper and lower sides of the projecting parts, as well as on the exposed side of the part fastened to the shoot. The fully developed pileus is of a whitish colour tinged with violet; the projecting part is about 5 mm. thick, and its upper surface is more uneven than its lower surface (PL. XXV, Figs. 1, 2).

By carefully detaching the young pileus from the substratum, numerous mycelial strands of unequal thickness may be observed on its lower margin (PL. XXV, Fig. 3). These strands are found on

almost every portion of the diseased roots, forming irregular networks of various complexity (PL. XXV, Fig. 4). They are $\frac{1}{2}$ –1 mm. thick and of a purplish brown colour like the young pileus; and as to their mode of ramification there seems to be no regularity. Without destroying even their finest branches, they can be very easily detached, with a needle, from the roots upon which they grow, to a length of several centimetres (PL. XXV, Fig. 5). They are often found free, either forming large groups in spaces left between the partly detached cork layers of old diseased roots, or solitarily in the soil.

The microscopical structure of the mycelial strand is different from that of *Agaricus melleus*, whose minute details are now well known from the excellent description given by the late Prof. De Bary.* In the present species the axial portion of the mycelial strand consists of thick-walled hyphæ, 3 μ . in diameter, mixed with a few finer ones; and the peripheral portion consists entirely of finer hyphæ (PL. XXVI, Fig. 1). In the transverse section of the strand this is more clearly seen (PL. XXVI, Fig. 2). In the mycelial strand of *Agaricus melleus* the hyphæ are so compactly arranged as to form a tissue as is clearly seen in the cross section;† but in the present species the hyphæ composing the strand are so loosely put together that they easily separate from one another, and in the cross section they present a circular and not angular form, since they are not pressed together so as to assume the latter form. Moreover the form of the cross section of the strand in *Agaricus melleus* is round, but in this species it is flattened. The thickening of the strand is effected either by the copious branching of a single hypha or by the coalescence of two or more strands. In the group of hyphæ formed by the first method, there is always an axial or original thick hypha

* De Bary, *Vergl. Morphol. u. Biol. d. Pilze*; Eng. trans. p. 23-29.

† See Fig. 11, p. 24, of the same book.

surrounded by finer ones which have been produced by its ramification (PL. XXVI, Fig. 3). As the strand grows, the branches of the original hypha also ramify ; and the secondary branches thus produced surround the primary branches, just as the latter surround the original hypha. In this way branches of higher orders are successively produced, and surround the branches of the next lower order. Ordinarily the branches of the hyphæ grow in one direction, but occasionally there are found those that grow in two opposite directions from the point of origination (PL. XXVI, Fig. 4). The older hyphæ or those lying towards the center of the strand are much more darkly coloured than the younger or those of the periphery. The mycelial strand of the fungus is found only on the surface of the host. When it makes its way into the tissues of the latter it usually forms longitudinally elongated masses, such as are seen in the interstices between the cork layers of the host (PL. XXVI, Fig. 9). Similar masses are also found on the surface. These masses of the hyphæ spread widely in the cambium zone and in the young bast, forming membrane-like expanded networks of whitish mycelia. These mycelia send out single colourless hyphæ, 1.5–1 μ . in diameter (PL. XXVI, Fig. 5), into the rind and wood, and especially into the dotted vessels. They also send out masses of coloured hyphæ to the surface of the host, from which are again developed ordinary external mycelial strands.

Crystalline spheres of calcium oxalate, $\frac{1}{10}$ – $\frac{1}{2}$ mm. in diameter (PL. XXVI, Fig. 6), are found in great numbers on those places where the white mycelial membranes abound. They consist of an enormous number of somewhat radially arranged wedge-shaped crystals (PL. XXVI, Figs. 7, 8), each of which is 20–30 μ . long and 10–15 μ . broad. If we examine one of these crystalline spheres under the microscope, taking care not to crush it, we see only the sides and broader ends of the wedge-shaped crystals ; and by crushing

it we can recognize the radial arrangement of the crystals. Prof. De Bary has described crystalline spheres of a similar nature found in the narrow cylindrical hyphæ of the mycelium of *Phallus caninus*.* Crystals of calcium oxalate of other forms, such as regular quadrate octohedra, rod-shape, &c., are also found in great abundance in the same place where the crystalline spheres are found.

The mycelia of the fungus form an enormous number of sclerotia in all parts of the diseased portion of the roots (PL. XXVII, Fig. 1, *a*). The sclerotia are irregularly roundish bodies 1–4 mm. in diameter, and are dark purplish brown in colour. If the nourishment in the sap-containing layers of the host plant becomes scanty by the parasitic action of the fungus, and also when the vegetative activity of the host plant is diminished in autumn, the interior of the lenticels and the interstices between the cork layers become filled with the sclerotia of the fungus, while the mycelial strands which remain outside spread widely on the surface of the roots. By carefully detaching the mycelial strands we can ascertain that they have no direct communication with the sclerotia. The number of sclerotia is different in different parts of the roots, according to the degree of the injury done by the fungus; and the greater the degree of the injury, the greater the number of the sclerotia. The formation of sclerotia does not take place on the outside of the host plant, but always in the inside or in the spaces partly exposed by the formation of fissures (PL. XXVII, Fig. 2). The sclerotia have a dark brown rind (PL. XXVII, Fig. 3, *b*), and a medulla of white soft tissue (Fig. 3, *a*) with a few air-conducting passages. The hyphæ of the medulla are cylindrical and septate, anastomosing with one another in a rather loose manner (Fig. 4, *a*), and are 4–5 μ . in diameter. Towards the surface of the sclerotia, the medulla passes gradually into the rind,

* De Bary, *Vergl. Morphol. u. Biol. d. Pilze*, Eng. trans. p. 11.

which consists of thicker-walled and shorter-celled hyphæ, forming a compact tissue without interstices (Fig. 4, *b*). In its younger stage the surface of the rind is felted over with the remains of dead hyphæ (Fig. 4, *c*). A series of five different colours—white, yellow brown, dark brown, rose violet, and dark violet brown—may be seen in the order stated, from the centre outwards in the section of the sclerotium.

As the mycelial strands gradually grow upwards, they aggregate into a few flat thick strands, more than 1 mm. broad. These strands spread themselves from the apices and unite into a thin broad layer, consisting of reticulated hyphal filaments and covering the base of the shoots of the host plant. As the development of this layer proceeds, the pileus is formed from it. The pileus is an irregularly roundish flat disk with a smooth velvety surface, and takes a purplish brown colour, leaving its margin whitish (PL. XXIV, Fig. 2, *a*). Thin radial sections of a fully developed pileus, show that its medullary stratum is composed of loosely anastomosing branched hyphæ, dark violet brown in colour, and 3–4 μ . in diameter (PL. XXVII, Fig. 5). Towards the outer surface of the pileus these hyphæ take a vertical position, and produce short and blunt branches (PL. XXVII, Figs. 6, 7). These branches of hyphæ are colourless and shortly septate, and form the hymenial layer. Some of them elongate here and there, and form the basidia, which are curved and 5–8 μ . in diameter. From the convex surface of the basidium are produced four sterigmata, which are pointed, slightly curved and 6–10 μ . in length (PL. XXVII, Figs. 8, 9, 10). The spores are formed singly on the apices of the sterigmata; they are ovoid, curved, 10–12 μ . long and 5–7 μ . broad (PL. XXVII, Fig. 11). The portion of the pileus attached to the substratum produces hairs or rhizoids on its inner surface, which penetrate into the substratum. But the horizontally projecting part of the pileus produces the hymenium on both surfaces, when it does

not lie flat on the ground. The internal structure of these two portions is, however, essentially the same.

In the medullary stratum of the pileus which lies on the ground, an immense number of minute algae, belonging to the genera *Conferva* and *Protococcus* (PL. XXVII, Fig. 16) are found in groups, very much like the gonidia of Lichens. On the higher parts of the stems and branches of old mulberry trees, are frequently found orbicular and brownish purple patches, from 1–10 cm. in diameter; they are commonly called “Kōyaku-byō” * of the mulberry tree. They resemble very much in their structure the young pileus of the species of *Helicobasidium* in question, except that the hyphæ in the pileus of the former are more slender than those of the latter, being only 2–3 μ . in diameter (PL. XXVII, Fig. 12). The sterigmata of the former are also very minute; and I have not been able clearly to determine their number on a basidium (PL. XXVII, Figs. 13, 14). Besides the ordinary slender basidia, 3 μ . in diameter, much thicker and segmented basidium-like extremities of hyphæ bearing no sterigmata are often seen in the hymenium (PL. XXVII, Fig. 15). Whether the orbicular patches just described simply represent a form of the present species or not can only be determined after further investigation. But I venture to say that it is probably a poorly nourished form of the latter.

In conclusion, I wish to express my thanks to Prof. R. Yatabe who has helped me throughout my work with valuable suggestions.

* The Japanese word *kōyaku* means a medical plaster; *byō*, disease.

Explanation of Figures in Plates XXIV—XXVII.

Plate XXIV.

Fig. 1. Sketch of the base of a young mulberry tree, injured by the disease at the roots *a, b*. The upper portion *a'* and the roots *c* are free from the disease; the lower portion *a'* of the roots *a* is completely disorganized. *Reduced.*

Fig. 2. Portion of the base of a shoot, showing the young pileus *a* of the fungus. *Natural size.*

Fig. 3. More advanced stage of a similar pileus with its projecting parts *a*. *Natural size.*

Fig. 4. Mature form of a similar pileus; *a* its projecting part; *b* its basal part. *Natural size.*

Plate XXV.

Fig. 1. Mature form of the pileus of the fungus, showing its upper surface. *Natural size.*

Fig. 2. Lower surface of the same. *Natural size.*

Fig. 3. Young stage of the pileus carefully detached from its substratum. *Natural size.*

Fig. 4. Portion of a diseased root, with mycelial strands of the fungus. *Natural size.*

Fig. 5. Portion of the mycelial strands detached. *Natural size.*

Fig. 6. Group of mycelial strands. *Natural size.*

Plate XXVI.

Fig. 1. Hyphæ of mycelial strands. $\times 440$.

Fig. 2. Cross section of the same. $\times 440$.

- Fig. 3.* Hyphæ of mycelial strands, showing the mode of ramification. ×440.
- Fig. 4.* A kind of branching in a similar hypha. ×440.
- Fig. 5.* White hyphæ in the tissues of the host plant. ×440.
- Fig. 6.* Crystalline spheres of calcium oxalate. ×5.
- Fig. 7.* A similar sphere much magnified. ×240.
- Fig. 8.* Wedge-shaped crystals *B* of the same; *A* showing their radiating structure. ×240.
- Fig. 9.* Masses of coloured mycelia *a* in the interstices of cork layers *b*. ×10.

Plate XXVII.

- Fig. 1.* Portion of a diseased root, with numerous sclerotia *a* of the fungus. *Natural size.*
- Fig. 2.* Longitudinal section of the bark of a root, showing the formation of sclerotia. ×5.
- Fig. 3.* Vertical section of a sclerotium; *a*, medulla; *b*, rind; *c*, remains of hyphæ. ×50.
- Fig. 4.* Portion of the same, showing its tissues; the letters correspond to those in Fig. 3. ×440.
- Fig. 5.* Hyphæ in the medullary stratum of the pileus. ×440.
- Figs. 6, 7.* Hyphæ in the hymenial layer of the pileus. ×440.
- Figs. 8, 9, 10.* Basidia with sterigmata and young spores. ×440.
- Fig. 11.* Mature spores. ×440.
- Fig. 12.* Hyphæ in the medullary stratum of the orbicular

patches on the higher parts of the stem and branches of an old mulberry tree. × 440.

Figs. 13, 14. Basidia of a similar patch. × 440.

Fig. 15. Basidium-like hypha of a similar patch. × 440.

Fig. 16. Algæ in the medullary stratum of the pileus ; *A, Conferva* ; *B, Protococcus*.



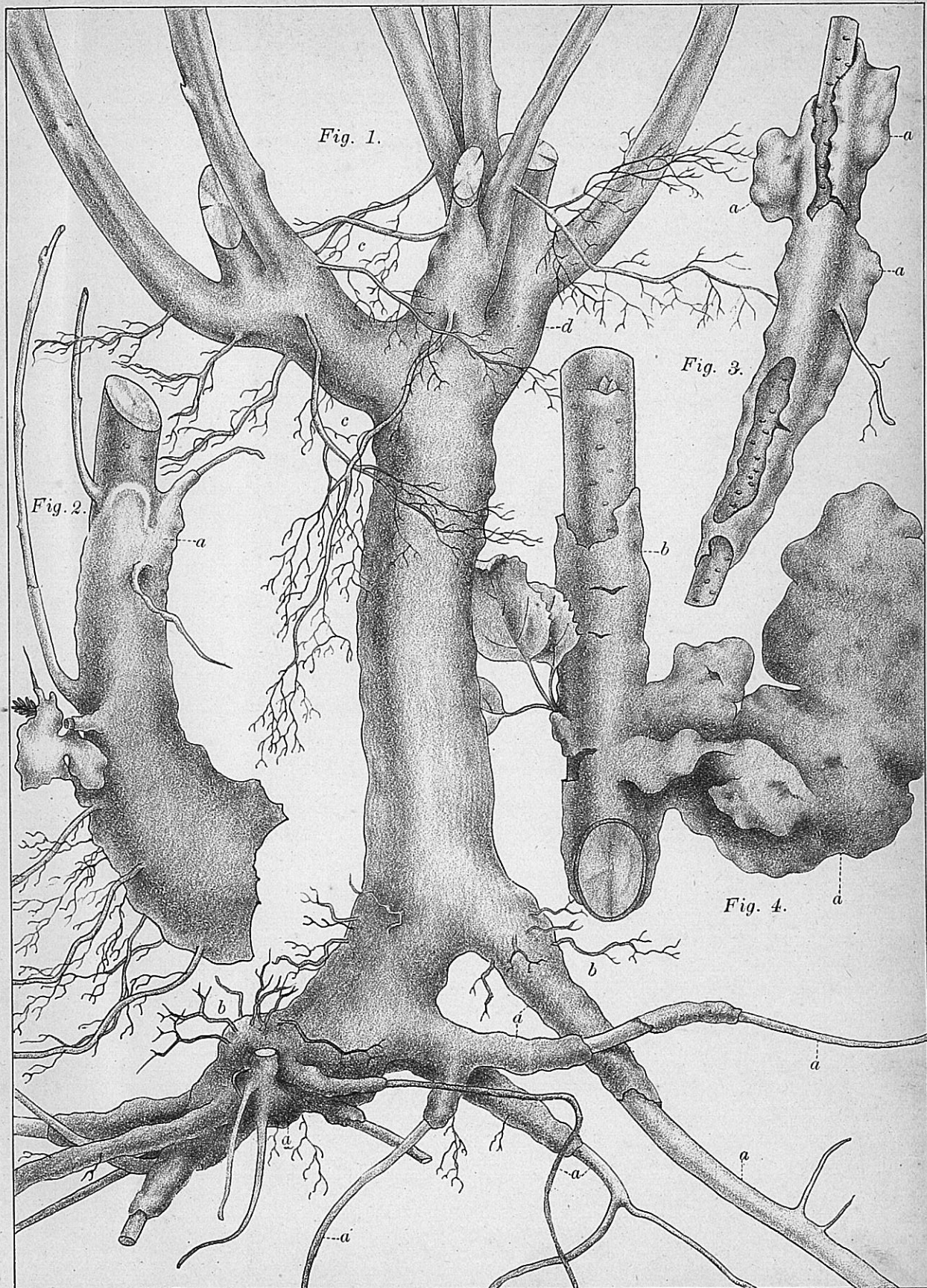


Fig. 1.

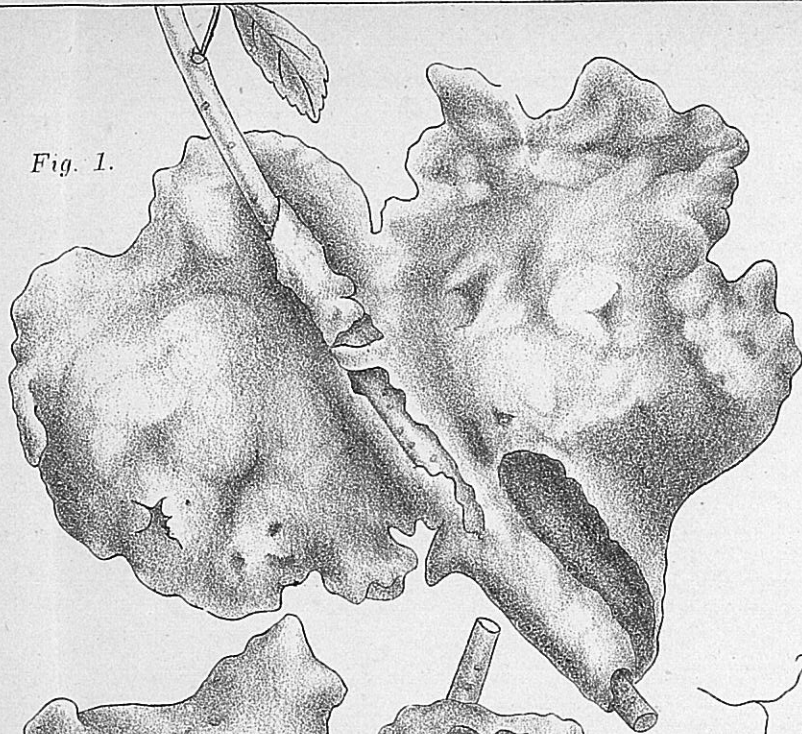


Fig. 4.



Fig. 5.

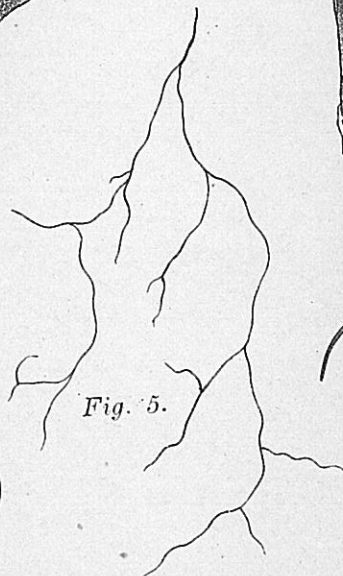


Fig. 2.

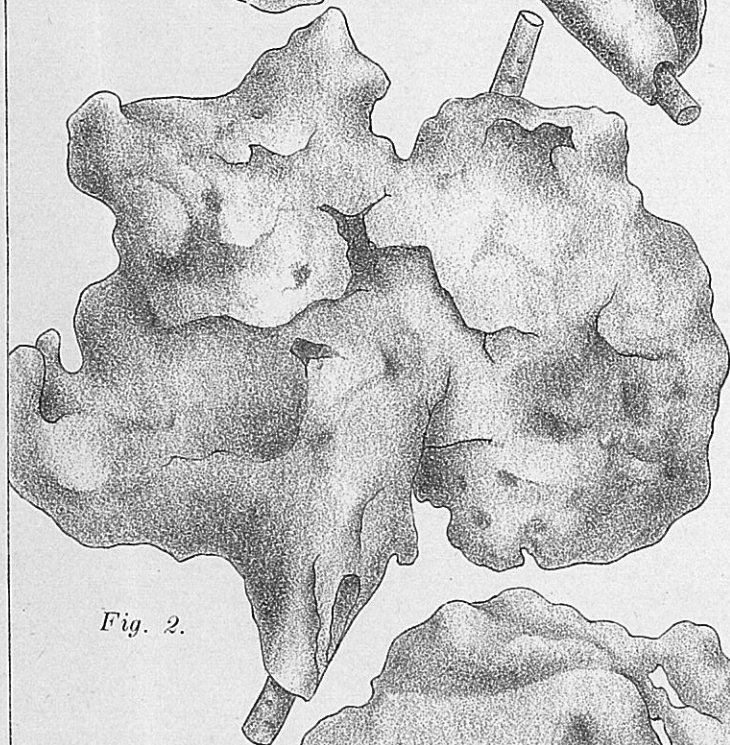


Fig. 3.

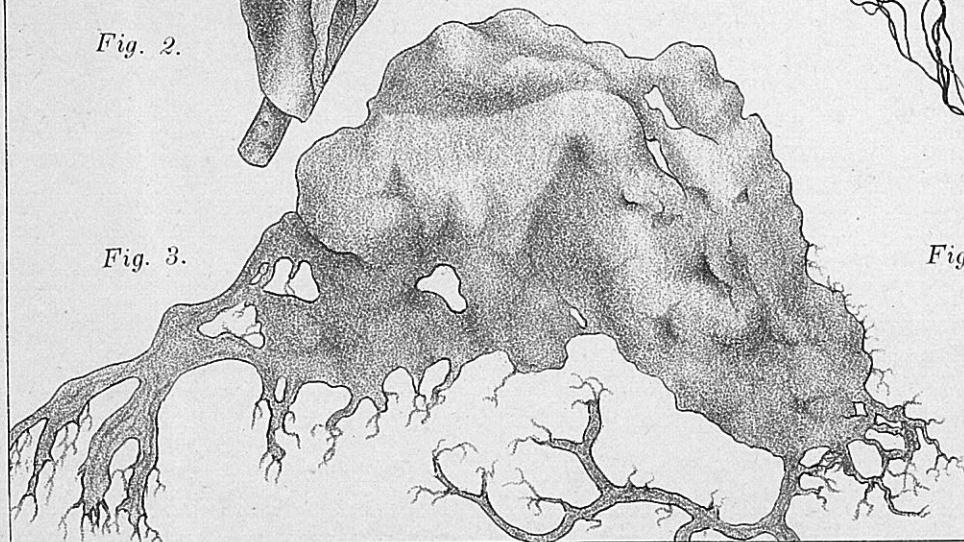
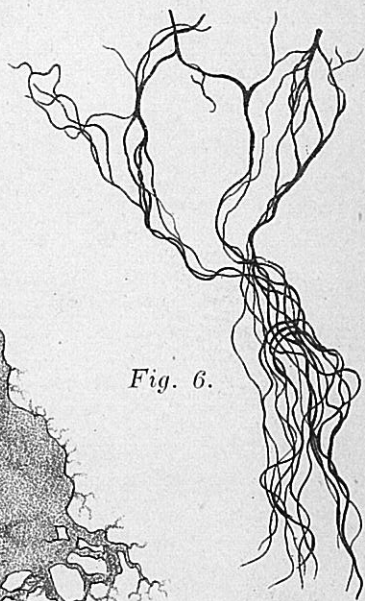


Fig. 6.



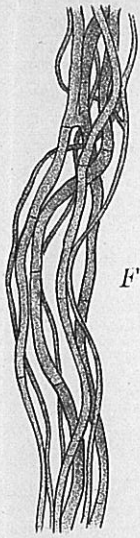


Fig. 1.

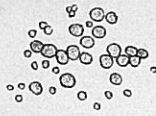


Fig. 2.



Fig. 4.

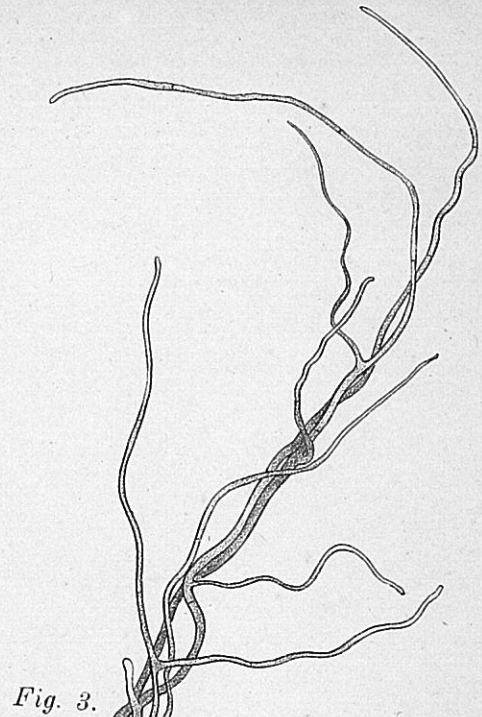


Fig. 3.

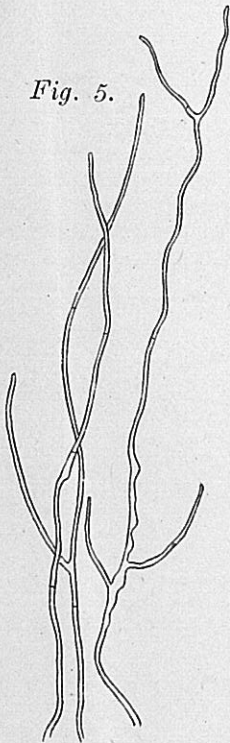


Fig. 5.

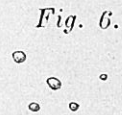


Fig. 6.

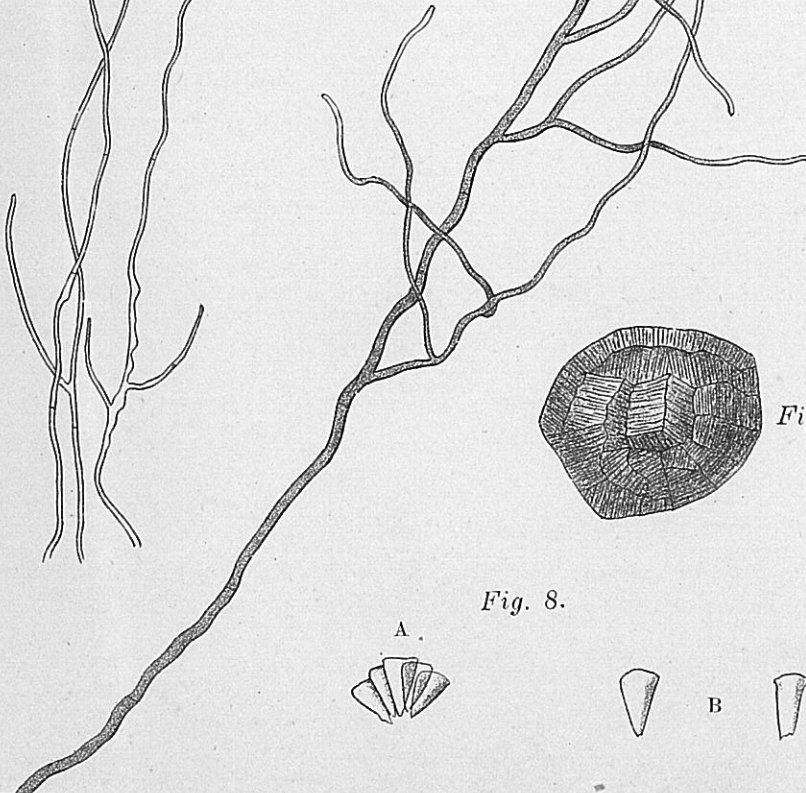


Fig. 8.

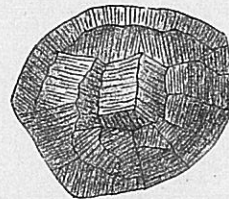


Fig. 7.



A.



B.



Fig. 9.

