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CONTENTS

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TORREY BOTANICAL CLUB

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A STUDY OF THE LACTARIAE OF THE UNITED STATES

BY

GERTRUDE SIMMONS BURLINGHAM

ISSUED MAY 26, 1908

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CONTENTS

LIST OF ILLUSTRATIONS

(The photographs are all four fifths of the natural size of the plants)

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INTRODUCTION

SCOPE AND AIM OF THE WORK

This study of the *Lactariae* has been limited to the United States, since, with the exception of a list of thirteen species from Nova Scotia,* and a few species from other provinces of Canada preserved in the herbarium of the N. Y. State Museum at Albany, no species have been reported from other parts of North America. In pursuance of the study the aim has been to observe the living plants in the field. Accordingly, for several summers, collections were made in the vicinity of Lake Ontario in Oswego County, New York. One season was spent in southern Vermont near Newfane, and in the summer of 1907 a study of the southern distribution of the genus was undertaken in the mountains of North Carolina about forty miles south of Asheville in the Pisgah Forest reserve, where the Biltmore Forest School is located during the summer.

The field study has been supplemented by the examination of dried specimens collected in various states, many of which collections are the property of the N. Y. Botanical Garden. Among these should be mentioned the herbarium of the late Professor L. M. Underwood, which contains species from Connecticut, Central New York, Indiana, and Alabama; the Earle collection from Connecticut, Alabama, Mississippi, and southeastern New York; the *Lactaria* herbarium of N. M. Glatfelter, including the specimens from which the determinations were made for his St. Louis list † as well as several species from Pennsylvania; specimens collected on Mt. Desert Island, Maine, by Miss V. S. White; species from Massachusetts collected by G. Morris; collections made in Maine, Pennsylvania, District of Columbia, Virginia, and Tennessee, by W. A. Murrill; some Delaware species collected by H. S. Jackson; collections made near Gainesville, Florida, by H. S. Fawcett; and specimens collected in Indiana, by G. W. Wilson. Several other collections were loaned to the Botanical Garden, thus facilitating the work very much. B. M. Longyear sent for

* MacKay, A. H. Fungi of Nova Scotia: a provisional list. Proc. and Trans. N. S. Inst. Sci. 11: 122–143. 1904.

† Preliminary list of higher fungi collected in the vicinity of St. Louis, Mo., from 1898 to 1905. Trans. Acad. Sci. St. Louis 16: 33–94. 1906.

examination the type specimens of his two Michigan species, while Kauffman sent his collection of *Lactariae* from Michigan. Through the courtesy of Dr. Bessey, I was enabled to examine the type of *L. villosus* Clements. Professor L. R. Jones kindly loaned the specimens of *Lactariae* in the herbarium of the University of Vermont, and Hanmer allowed me the privilege of examining his entire collection of *Lactariae* from Connecticut, including the specimens from which the determinations were made in the White list.*

Through the courtesy of Professor Peck, I was greatly assisted in examining the herbarium of the N. Y. State Museum at Albany. In addition to the New York specimens it includes species from several other states. Here are found the Peck type specimens. Professor Peck also furnished me with additional notes upon some of these, as will appear under the species. I found that in the Schweinitz herbarium, which is at the Academy of Natural Sciences of Philadelphia, not a specimen of *Lactaria* remains. The Herbst collection of fungi from near Allentown, Pennsylvania, has recently been turned over to the Academy of Natural Sciences of Philadelphia, and, although it has not yet been systematically arranged, I was able with the assistance of Mr. Stewardson Brown to pick out the *Lactariae* which it contains. Only three specimens given in his list are represented, but there are four in the collection which are not listed. The Frost collection of fungi is now accessible at the University of Vermont, at Burlington. It contains in good condition specimens of *L. hygrophoroides* B. & C., *L. scrobiculata* (Scop.) Fr., *L. insulsa* Fr., and *L. pergamena* (Swartz) Fr.; in poor condition, *L. trivialis* Fr. and *L. theiogala* (Bull.) Fr.; also, four species indicated as new, one with a brief description. The last are so covered with mold, however, as to conceal the specific characteristics.

Unfortunately, the specimens from which the determinations were made in the lists of *Lactariae* from some of the western states have not been preserved. This is true of Bundy's Wisconsin list of fungi,† Johnson's Mycological Flora of Minnesota,‡ the

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* White, E. A. A preliminary report on the Hymeniales of Connecticut. Conn. Geol. and Nat. Hist. Surv. Bull. 3: 1–81. 1905.

† Geol. of Wis. Surv. 1: 396–401. 1883.

‡ Bull. Minn. Acad. Nat. Sci. 1876: 254–257. 1877.

Pacific Coast Fungi by Harkness and Moore, * and Morgan's treatment of *Lactarius* in his Mycologic Flora of the Miami Valley, Ohio.† The specimens reported from Maryland by Miss Banning are so perfectly reproduced in her Folio of Maryland Fungi, which is in the State Museum at Albany, N. Y., that there is no doubt as to the species which she had in hand, and I have not hesitated to accept her list. With this exception, the distribution of species as given in this paper has been based upon the examination of the specimens themselves.

HISTORICAL

The genus *Lactaria* was established by Persoon in 1797.‡ He defines the genus as follows: "Pileus fleshy, depressed, lamellae latex-bearing. If the pileus is broken and the lamellae a little irritated, they pour out a milky liquor for the most part acrid, in which respect these fungi agree with some higher plants; and this gives me a handle so that I am able to separate them under a peculiar genus from other agarics," etc. Under the genus he describes six species, four of which are readily assigned; namely, *L. piperata* (L.) Pers., *L. lateritia* Pers. [= *L. deliciosa* (L.) Fr.], *L. pallida* Pers., *L. torminosa* (Schaeff.) Pers.; of these, *L. piperata* (L.) Pers. stands as the type of the genus by reason of precedence. In his later books, Persoon returns to his earlier nomenclature, *Agaricus lactifluus* being used as equivalent to *Lactaria*, the species being written trinomially; nevertheless, to him belongs the credit of first recognizing the genus. Roussel § in 1806 used *Lactifluus* as a generic name. Regardless of these two attempts at separating the group as a genus, Fries classified the *Lactariae* under *Agaricus* both in the Observationes Mycologicae and in the Systema Mycologicum, in the latter of which he introduced the tribal name *Galorrheus*.‖ In the Epicrisis,¶ published in 1838, however, he took up the generic name *Lactarius*, the name by which the genus was henceforth designated until Schröter recognized the *Lactaria* of Persoon in his treatment of the genus in Cohn's Kryptogamen-Flora von

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* Cat. Pacif. Coast Fungi 9. 1880.

† Jour. Cincinnati Soc. Nat. Hist. 6: 182–185. 1883.

‡ Tentamen dispositionis methodicae fungorum 63–65. 1797.

§ Flore du Calvados 66. 1806.

‖ Syst. Myc. 1: 61. 1821.

¶ Epicr. 333. 1838.

Schlesien. * And Hennings has followed Schröter in his treatment of the genus in the Engler & Prantl, Natürlichen Pflanzenfamilien.

Schröter has separated **Lactaria plinthogala** (Otto) † and *Lactaria ligniota* Fr. under the generic name *Lactariella* ‡ upon the basis of the yellow spores. But if the spore color is taken as a generic character, one must include other yellow-spored *Lactariae*, namely *L. deliciosa*, *L. subpurpurea*, and related species, as well as *L. delicata*, *L. crocea*, and *L. trivialis*, which are widely divergent from *L. plinthogala* and *L. ligniota*. Furthermore, *L. Gerardii*, a white-spored species, is so closely related to these two species as to suggest an origin from them. Hennings, also, has described one latex-bearing species from Africa under the generic name *Lactariopsis*,§ the distinctive characteristic being the presence of a membranaceous veil connecting the stem with the pileus. After a careful study of the morphological and physiological characters of the species forming the genus *Lactaria* as it now stands, I have come to the conclusion that with the exception of the tribe *Pleuropus* Fr., which is not represented in America, there is not sufficient differentiation to form the basis of separation into smaller genera. The morphological characters which might serve as generic traits are neither constant enough in any group nor sufficiently limited to the one group. Taking for example the tomentose margin, we find it combined with a viscid pileus in *L. torminosa* (Schaeff.) Pers., and with a dry pileus in *L. deceptiva* Peck; while, if *L. regalis* Peck shall prove to be a valid species or only a form of *L. resima* Fr., it will give us in either case two physiologically and naturally related plants, one with tomentose, the other with glabrous margin. Again, among the species classified by Fries under the *Piperati*, we find glabrous forms like *L. piperata* (L.) Fr., and tomentose ones like *L. vellerea* Fr., yet there is no doubt but that these two are very closely related. In every group except the *Piperatae* there are species showing a deepening color in the mature gills, together with more or less pruinosity. The homogeneity of the genus is,

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* 3: 534. 1889.

† *Agaricus plinthogalus* Otto, Versuch Agar. 75. 1816.
Agaricus fuliginosus Fr. Syst. Myc. 1: 73. 1821.
Lactarius fuliginosus Fr. Epicr. 348. 1838.

‡ Krypt.-Fl. Schles. 3: 544. 1889.

§ Bot. Jahrb. 30: 51. 1901.

then, very strong, and the most pronounced differences are physiological and are lost in the dried specimens.

In the present paper I propose to arrange the species of the genus in seventeen natural groups, each group being centered about a species which, by reason of possessing in a marked degree the characteristics found in the other species, shall stand as the type of the group. In many instances, the first described species has been found to combine the most of these characteristics. In speaking of this as a natural arrangement, I mean that each group is made up of those species which seem to be most closely related both morphologically and physiologically, and often so closely resemble each other as to be confused by the casual observer. In many groups the relationship is so marked that it is easy to conceive of the species as mutants from the type. It is a grouping which deals primarily with the living plants.

These groups I have in turn segregated into five sections: *Piperites*, *Sublimacina*, *Limacina*, *Russularia*, and *Dapetes*. Each of the last two embraces the species included by Fries in his so-called "tribe"* of the same name. On the other hand, the species which he included under the "tribe" *Piperites*, I have classified in three sections of equal rank with *Dapetes* and *Russularia*. The section *Sublimacina* is made up of species possessing characteristics of both the *Piperites* and the *Limacina*. It is not intended that this grouping shall multiply the names to be used in classification, but that it shall be an aid in the determination of species and in the comprehension of relationship.

THE DISTRIBUTION OF THE LACTARIAE IN THE UNITED STATES AND THE RELATION OF DISTRIBUTION TO LATITUDE, ELEVATION, AND FOREST CONDITIONS

Some *Lactariae* have been reported from all of the states east of the Mississippi River excepting Illinois and Kentucky. In the region west of the Mississippi, fourteen species have been reported from Missouri, three from Kansas.† two from Colorado, one from Nebraska, and ten from California.† This apparently limited dis-

* According to our present conception of the term *tribe*, Fries used it incorrectly. He applied the name to each of the four groups into which he divided the genus, namely: *Piperites*, *Dapetes*, *Russularia*, and *Pleuropus*. Hym. Eur. 422–439. 1821.

† I have seen only one specimen from Kansas and only a few from California.

tribution of the genus in the West is explained by the fact that in some of the western states no collections of fleshy fungi have been made. But enough has been done to indicate that some species will be found in any state, wherever the forest conditions are favorable.

Within the limits of the United States, latitude seems to affect the distribution of *Lactariae* chiefly in so far as it controls the character of the forest. *Lactaria Indigo* Schw., which grows in pine woods, has been found from Florida to the Adirondack region. *Lactaria deliciosa*, *L. subpurpurea*, and *L. atroviridis* have a like distribution. Out of thirty-one species which I found in North Carolina, twenty-three occur as far north as Vermont, one has a northern distribution in Europe, *L. Peckii* has been found as far north as Long Island, and six others have not been described before. *L. salmonea* Peck, from Alabama, and *L. subvellerea* Peck, have not as yet been found north of North Carolina.

Elevation also influences the distribution of species in proportion as it produces different ecological conditions. At 500 meters in Vermont, where the oaks are practically lacking, *L. piperata* (L.) Fr. and *L. lactiflua* L. rarely occur, while at 1,000 to 1,200 meters in North Carolina, where oaks and chestnuts form about 70 per cent. of the forest, these species are very abundant, but they disappear as one approaches the spruce line. At this altitude one begins to notice the combined effects of latitude and elevation. The condition of spruce forests in the southern states differs from that in the North. The greater elevation of the dividing line between oaks and spruces causes a greater daily range of temperature and the nights may be too cold for certain spruce-loving species. On this account it is probable that a species like *L. resima* Fr. will be found to be limited to northern forests. In the southern mountains below the spruce line, on account of the great humidity there will be not only a profusion of fungi but one might expect to find certain species which would thrive only under such moisture conditions. It is also possible that the unglaciated condition of the southern states may account for the occurrence of some species which seem to be limited to that region. This can not be stated with certainty until further field work proves that such species as *L. speciosa*, *L. agglutinata*, *L. salmonea*, etc., are not found north of the glacial line. Not enough is known about

the *Lactariae* in California and Oregon to form a basis for generalization.

The species of trees growing in a forest, then, seem to be the greatest factor in determining what species of *Lactaria* shall grow there. In oak or chestnut woods one may be sure of finding *L. lactiflua* L. and *L. piperata* (L.) Fr.; in beech woods, *L. cinerea* Peck and often *L. vellerea* Fr.; in hemlock woods, *L. deliciosa* (L.) Fr., *L. subpurpurea* Peck, and *L. deceptiva* Peck; other species seem to grow in any fairly moist deciduous forest. This limitation of species to the vicinity of a particular species of tree is undoubtedly largely due to the adaptation of the humus there found to the growth of the fungus. Bourquelot * claims to have found in *L. controversa* Fr., which grows at the foot of poplars, a ferment analogous to emulsin, which might indicate a symbiotic relation between the two. He was not able to find such a ferment in *L. vellerea* Fr. Noack † states that he found a mycorhiza relationship between *L. piperata* (L.) Fr. and *Fagus silvatica* and *Quercus pedunculata*, also between *L. vellerea* Fr. and the beech.

THE STRUCTURE, INTERNAL MORPHOLOGY, AND PHYSIOLOGY OF THE SPOROPHORE, INCLUDING COLOR CHANGES AND REACTIONS

The *Lactariae* and *Russulae* are characterized by a vesiculose structure, that is, by the presence of parenchyma-like cells scattered among the filamentous hyphae. Fayod ‡ designates these tissues as fundamental, consisting of isodiametric sphaerocysts, and connective tissue or slender hyphae. The sphaerocysts are grouped in the filamentous tissue, and DeBary § suggested that they might be enlarged branches of these hyphae constricted at rather regular intervals, so that the branch might be compared to a rosary. The sphaerocysts are sometimes grouped so as to appear in a cross-section of the stem like a rosette, the center of the rosette being the cross-section of a thin-walled tube which pur-

* Bourquelot, E. Présence d'un ferment analogue à l'émulsine dans les champignons et en particulier dans ceux qui sont parasites des arbres ou vivent sur le bois. Bull. Soc. Myc. Fr. **10**: 49–54. 1894.

† Ueber mykorhizenbildende Pilze. Bot. Zeit. **47**: 389. 1889.

‡ Ann. Sci. Nat. Bot. VII. **9**: 322–330. 1889.

§ Morph. Fung. Mycet. and Bact. 298–301. *f. 136*. 1887. [Engl. transl.]

sues a winding course through the fundamental tissue. The cortical tissue is made up of the filamentous hyphae and bands of this tissue run through the interior of the sporophore among the groups of sphaerocysts. There are also oil-vessels which Fayod * regards as derived from the connective tissue in a manner similar to the origin of the laticiferous vessels in the Papaveraceæ. In the *Lactariae* there is a well-developed system of latex-vessels, and it is the presence of these that distinguishes the genus *Lactaria* from the closely related genus *Russula*.

The latex-tubes are large thin-walled hyphae about 10–12 μ in diameter running through the bundles of connective tissue and sometimes approaching the groups of sphaerocysts but not coursing through this tissue. In the stem the tubes extend longitudinally and in the pileus they are for the most part parallel to the surface. They do not anastomose so as to form a network, but are connected now and then by short cross branches and in the trama they branch more freely. Fayod considers these latex-vessels to be modified sphaerocysts, since they sometimes end among the filamentous hyphae like sphaerocysts and since it is not uncommon to find these latter elongated and filled with granular colored protoplasm, as well as cylindrical with hyaline contents. He also regards the formation of the latex-vessels to be parallel with their formation in the higher plants.

According to Boudier† the latex is an emulsion of a resinous substance in a liquid which contains albuminoids, and it is this resinous product which gives to the latex its characteristic taste. Errera‡ states that the latex-tubes do not contain glycogen. The chemistry of this milky fluid has not, however, been sufficiently worked out. Errera advances the hypothesis that the fundamental tissue is the place for the deposit of hydrocarbon material while the filamentous hyphae are the routes along which the proteid material returns to the developing organs. Fayod § has also observed that glycogen is formed in the sphaerocysts and that the material nec-

* Cf. Godfrin, J. Homologie des hyphes vasculaires des agaricinés. Bull. Soc. Myc. Fr. **18**: 147–150. 1902.

† Boudier, E. Des champignons au point de vue de leurs caractères usuels chimiques et toxicologiques, 78–82. 1866.

‡ Sur le glycogène chez les Basidiomycètes 30, 31. 1885.

§ Fayod, *loc. cit.*

essary for the formation of the glycogen is carried through the filamentous hyphae and that later the nourishment returns along the same route to the hymenium as it is needed. Errera further suggests that the filamentous hyphae are elements of support. This can be true, of course, only in an elementary way.

The cause of the change in color of the latex of certain species of *Lactariae* has been somewhat recently studied by Bourquelot and Bertrand.* They came to the conclusion that the phenomena of coloration are often due to the presence of an oxidizing ferment in the cells which acts upon a particular chromogen contained in the mushroom. Only two out of twenty species examined showed the absence of an oxidizing ferment. These were *L. subdulcis* (Bull.) and *L. mitissima* Fr. When the latex changes color this chromogen is in solution in it and the oxidizing ferment concealed also in the solution acts upon the chromogen as soon as they come together in the air, as in the case of a wound, thereby changing the chromogen bodies into a colored pigment. It is to be assumed that in such species as *L. deliciosa* (L.) Fr. the mushroom is so rich in oxidizing substances that this color change will result in the outer layers of cells. This view is upheld by the fact that when a leaf adheres firmly to the surface the epidermis is frequently colorless. The latex in the *Dapetes* is either colored in the living plant or the change takes place so instantly when the flesh is broken that one cannot perceive it. If the color is present in the latex while within the plant, it is possible that the oxidizing ferments are able to use the oxygen which enters the plant by respiration. If this theory should be true we might expect variations of color under different temperatures and light conditions,† since these factors affect the respiration of the mushroom. But while it has been shown that light diminishes respiration, certain species are brighter-colored when growing in open woods. *L. theiogala*

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* Bertrand, G. Bull. Soc. Chim. Paris III. **15**: 793. 1896.

Bourquelot, E. & Bertrand G. Les ferments oxydants dans les champignons. Bull. Soc. Myc. Fr. **12**: 18–26. 1896; Sur la coloration des tissus et du suc de certains champignons au contact de l'air. Bull. Soc. Myc. Fr. **12**: 27–32. 1896.

Bourquelot, E. Sur la présence générale, dans les champignons, d'un ferment oxydant agissant sur la tyrosine; sur le mécanisme de la coloration du chapeau de ces végétaux. Bull. Soc. Myc. Fr. **13**: 65–72. 1897.

† Bonnier & Mangin. Ann. Sci. Nat. Bot. VI. **17**: 210–302. 1884.

(Bull.) Fr. is nearly white when growing in dense shade but in a more exposed place it varies from yellowish-salmon to fulvous. In *L. lactiflua*, however, which varies greatly in color, I have not been able to detect any fixed relation between coloration and light. It is thus probable that color depends upon the interaction of a number of factors, and any one factor may not have the same effect upon color in two different species. In *Tricholoma Russula*, Bourquelot * was unable to find an oxidase ferment, yet color changes occur in the broken flesh, hence it seems possible that in some cases the action of the air alone is sufficient to cause a color change. Thus far, two oxidases have been identified in the mushrooms, tyrosinase and laccase, both of which occur in the *Lactariae*. No work has been done along this line upon the American species of *Lactaria*, and much investigation is needed before the chemistry and physiology of the genus will be understood.

The accompanying analysis of three species of *Lactariae* by Margewicz is taken from Schenck's Handbuch der Botanik (**4**: 391. 1890). The analysis was made from fresh young specimens. Bourquelot has made a study of the carbohydrates in several species of *Lactaria*. With the exception of *L. lactiflua* (L.), which contained volemite, mannite was present in all the species which he tested in the dried state. He found that the proportion of carbohydrate varies in different plants and in different specimens of the same species and that drying produces important differences both in the proportion and the nature of the substances. In *L. piperata* the trehalose disappears and is replaced by mannite. In other species the glucose which is present as a trace in the fresh plant is found in large proportions in the dried plant. Bourquelot's † analysis differs from that of Margewicz. From Gerard's ‡ studies of the oils in *L. vellerea* and *L. piperata*, we find that the former contains stearic acid, and the volatile acids, formic, acetic, and butyric, while oleic acid is present in a free state. Lecithine is probably present.

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* Bull. Soc. Myc. Fr. **13**: 65–72. 1897.

† Bourquelot, E. Matières sucrées continues dans les champignons. Bull. Soc. Myc. Fr. **8**: 196–208. 1892; Les matières sucrées chez les lactaires. Bull. Soc. Myc. Fr. **5**: 143–163. 1889.

‡ Gerard, M. E. Sur les matières grasses de deux champignons. Bull. Soc. Myc. Fr. **6**: 115–128. 1890.

Analysis.	In fresh plant.		In the dry substance.						
	Solid.	Water.	Proteid.	Fat.	Mannite.	Sugar.	Ash.	Cellulose.	Waste.
L. torminosa	*P.* 10.17	89.83	39.14	5.34	13.14	1.98	7.37	28.93	4.10
	S. 8.82	91.18	26.37	4.01	15.71	4.31	5.27	38.86	5.47
L. piperata	*P.* 9.83	90.17	32.21	6.91	13.47	4.17	7.13	30.30	5.81
	S. 11.77	88.23	28.35	4.72	12.17	4.13	8.43	38.04	4.16
L. deliciosa	*P.* 10.01	89.99	38.12	7.37	12.91	1.49	8.14	27.42	4.55
	S. 8.90	91.10	27.00	4.20	11.57	5.27	8.48	39.27	4.21

P = pileus. *S* = stem.

ECONOMIC VALUE

So far as is known, none of the *Lactariae* are seriously poisonous, although some are considered somewhat poisonous, while a large number of the species are edible. Whenever the edible qualities are known, I have indicated it at the end of the description of the species, following, in every instance, the conservative opinion.

NOMENCLATURE

In the matter of nomenclature, I have followed the rules of the American Code.* According to this, under canon 16 (*c*), *Lactarius* Fr. is to be regarded as a homonym in the sense that it is a variation from *Lactaria* Pers. merely in the spelling of the word; so that while the latter form must be retained because of priority, the name *Lactarius* is considered as practically identical with it, and the transfer of a species from *Lactarius* Fr. to *Lactaria* Pers. is not to be looked upon as making new combinations. But in all cases I have attempted to show which form was used by the one describing the species, as well as to indicate any subsequent correction. For example, "*Lactaria pergamena* (Swartz) Fr. Epicr. 340. 1838 [as *Lactarius*]. — Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 537. 1889," would be explained as follows: The species was described by Swartz under the specific name *pergamena*, transferred from *Agaricus* to *Lactaria* by Fries under the form *Lactarius pergamenus*, and later corrected by Schröter to read *Lactaria pergamena*.

* Bull. Torrey Club 34: 167–178. 1907.

COLOR-SCHEME USED, AND EXPLANATION OF PHOTOGRAPHIC METHODS

In the description of the colors of the mushrooms, I have used the Répertoire de Couleurs published by the Société Française des Chrysanthémistes, which contains 365 color-plates, most of the colors being produced in four tones. The plates represent living rather than metallic colors and are for this reason admirably adapted to the use of the mycologist. In the description of species the numbers in parenthesis after the color refer to the plate and tone in the Répertoire.

For the accompanying plates perfectly fresh representative plants were photographed four-fifths natural size on orthochromatic plates.

The specimens photographed were all collected in the "Pink Beds" region, in the Pisgah Forest reserve, about forty miles south of Asheville, North Carolina.

Much of this work was completed under the direction of Professor L. M. Underwood, whose assistance and inspiring encouragement I am glad to acknowledge. Many thanks are due also to Professor F. S. Earle for reading the manuscript.

Order *AGARICALES*

Family **AGARICACEAE**

Genus LACTARIA

Sections, PIPERITES, SUBLIMACINA, LIMACINA, RUSSULARIA, AND DAPETES

Groups, 17, as in following synopsis of sections and groups, etc.

Synopsis of sections and groups

*** Latex white at first (except in *L. salmonea* in XV)**

α. PIPERITES. Gills becoming neither darker with age nor pruinose; latex usually very acrid.

Pileus without a pellicle, absolutely dry.

Color white. — I. PIPERATAE.

Color dark. — II. RUSTICANAE.

Pileus viscid when wet.

Margin involute, densely tomentose or villose. — III. TORMINOSAE.

β. SUBLIMACINA. Gills becoming somewhat deeper-colored with age and pruinose; pileus very viscid, margin involute and more or less downy-tomentose at first; latex less acrid than in α or γ.

Latex white, unchanging. — V. AGGLUTINATAE.

Latex becoming yellow. — IV. CROCEAE.

Latex or wounds becoming lilac. — VI. ASPIDEAE.

γ. LIMACINA. Gills unchanged with age or sometimes slightly darker in *Triviales* and slightly pruinose; pileus very viscid, margin absolutely naked; latex very acrid.

Pileus some shade of gray or brown or red. — VIII. TRIVIALES.

Pileus some shade of yellow. — VII. INSULSAE.

δ. RUSSULARIA. Gills decidedly darker when mature, and pruinose; latex mild or tardily acrid except in *L. rufa* and *L. chrysorhea*.

Pileus viscid when wet, never slimy, soon dry.

Latex not becoming yellow or red.

Pileus grayish. — XI. CINEREAE.

Pileus pale leather-colored to fawn or mahogany. — X. QUIETAE.

Latex becoming yellow. — XII. THEIOGALAE.

Pileus not viscid when wet.

Surface glabrous, polished, or sometimes areolate.

Flesh thin, stem slender. — XVII. CAMPHORATAE.

Flesh thick, firm, stem stout. — XVI. LACTIFLUAE.

Surface pruinose to velvety.

Color some shade of fulvous. — XVI. LACTIFLUAE.

Color white or some shade of brown. — XV. PLINTHOGALAE.

Surface minutely tomentose or squamulose.

Color some shade of gray. — XIV. GRISEAE.

Color testaceous to fulvous or isabelline. — XIII. HELVAE.

** Latex bright-colored from the first

ε. DAPETES. Pileus somewhat viscid when wet, spores yellowish, latex not very acrid; plants edible.

Wounds becoming greenish, at least after some time. IX. DELICIOSAE.
Wounds not becoming greenish. XV. *L. salmonea*.

Key to the known species of Lactaria in the United States*

Latex bright-colored from the first. A
Latex white, unchanging. B
Latex becoming yellow, at least where in contact with the flesh. C
Latex becoming lilac, at least where in contact with the flesh. D
Latex becoming salmon-colored, or reddish, at least where in contact with the flesh. E
Latex becoming glaucous-green. F

A

Latex bright-colored from the first

1. Pileus more or less zonate. 2
   Pileus azonate, whitish, latex salmon-colored. 57. *L. salmonea.*
2. Latex indigo-blue or paler. 33. *L. Indigo.*
   Latex dark-red. 32. *L. subpurpurea.*
   Latex orange-colored, then red-orange. 30. *L. deliciosa.*
   Latex saffron-yellow. 31. *L. Chelidonium.*

B

Latex white, unchanging

Pileus never viscid. § I
Pileus viscid when young or wet. § II

§ I

1. Latex very acrid. 2
   Latex mild or tardily acrid. 11
2. Pileus white. 3
   Pileus colored. 8
3. Surface glabrous. 4
   Surface not glabrous. 6
4. Margin naked, plants large. 5
   Margin silky, plants small. 7. *L. involuta.*
5. Flesh thin, gills becoming straw-colored, 1 mm. broad. 2. *L. pergamena.*
   Flesh thick, gills dichotomously branching, 2 mm. broad. 1. *L. piperata.*
6. Surface velvety-tomentose. 7
   Surface glabrous or torn, margin cottony-tomentose. 5. *L. deceptiva.*
7. Gills distant, broad. 3. *L. vellerea.*
   Gills close, narrow, cinnamon-colored in drying. 4. *L. subvellerea.*
8. Pileus glabrous, at least when mature. 9
   Pileus scabrous-hairy, olivaceous. 9. *L. atroviridis.*
9. Red. 10
   Gray, mixed with brown, zonate, moist. 8. *L. rusticana.*
10. Umbonate. 44. *L. rufa.*

* In the keys preceding the groups will be found the doubtful American species and the European species which have been reported from the United States, but the occurrence of which is uncertain.

	Without umbo.	47. *L. rufula.*
11.	Pileus glabrous.	12
	Pileus squamulose to floccose-squamulose.	21
	Pileus velvety, or minutely tomentose.	26
12.	Gills not changing color where wounded.	13
	Gills changing color where wounded.	18
13.	Pileus fulvous to isabelline.	14
	Pileus putty-colored, stem and gills concolorous.	53. *L. Sumstinei.*
14.	Pileus zonate when moist.	69. *L. mutabilis.*
	Pileus azonate.	15
15.	Latex white or sometimes bluish-white to watery and thin.	16
	Latex whey-colored, pileus fading.	67. *L. seriflua.*
16.	Pileus polished, not fading.	17
	Pileus becoming areolate, fading, latex watery.	65. *L. rimosella.*
17.	Odor none.	66. *L. subdulcis.*
	Aromatic, stronger in drying.	64. *L. camphorata.*
18.	Gills becoming greenish where wounded.	19
	Gills becoming brown where wounded.	20
19.	Pileus about 3 cm. broad, umber-colored.	70. *L. parva.*
	Pileus up to 7.5 cm. broad, grayish, often roughened.	71. *L. varia.*
20.	Pileus azonate.	58. *L. lactiflua.*
	Pileus zonate.	60. *L. ichorata.*
21.	Pileus fulvous to isabelline.	22
	Pileus gray.	23
22.	Odor none, latex white.	46. *L. alpina.*
	Aromatic, latex watery.	43. *L. helva.*
23.	Odor none.	24
	Aromatic.	50. *L. glyciosma.*
24.	Pileus azonate, floccose-squamulose.	48. *L. grisea.*
	Pileus zonate.	25
25.	Plants very small, blue-black to slate-colored, stem glabrous.	49. *L. Bensleyae.*
	Plants larger, paler, stem pubescent.	51. *L. Hibbardae.*
26.	Pileus azonate.	27
	Pileus zonate, brick-red.	45. *L. Peckii.*
27.	Wounds becoming brown or fulvous.	28
	Wounds not changing color.	29
28.	Pileus yellowish-buff, gills close.	62. *L. luteola.*
	Pileus Vandyke-brown, corrugated.	61. *L. corrugis.*
29.	Pileus brown, gills distant.	55. *L. Gerardii.*
	Pileus golden-fulvous.	31
30.	Gills distant.	59. *L. hygrophoroides.*
	Gills close.	63. *L. subvelutina.*

§ II. Pileus viscid when young or wet

1.	Latex acrid.	2
	Latex mild or slowly acrid.	9
2.	Margin of pileus involute at first, with long tomentum.	3
	Margin of pileus involute at first, with tomentum about 1 mm. long, soon naked.	4
	Margin of pileus naked, pileus glabrous.	5
3.	Pileus whitish, entirely covered with matted tomentum, azonate.	11. *L. cilicioides.*
	Pileus yellowish, glabrous in the center, zonate.	10. *L. torminosa.*

4.	Pileus white, zonate, sparsely covered with coarse tomentum.	18. *L. lanuginosa.*
	Pileus buff, papillate when wet, squamulose when dry.	17. *L. agglutinata.*
	Pileus olivaceous-umber.	19. *L. turpis.*
5.	Pileus yellowish to orange.	6
	Pileus gray.	7
	Pileus red, azonate.	28. *L. hysgina.*
6.	Zonate, spores yellowish.	24. *L. insulsa.*
	Azonate, spores white.	25. *L. affinis.*
7.	Wounds of the gills becoming glaucous-green.	8
	Wounds not changing, pileus zoned with umber, fading.	27. *L. circellata.*
8.	Pileus gray to putty-colored, sometimes lilac-tinted, spores yellow.	26. *L. trivialis.*
	Pileus sepia, spores white.	29. *L. mucida.*
9.	Pileus gray, gills not changing color where wounded.	39. *L. cinerea.*
	Pileus red.	10
	Pileus fulvous to pale-isabelline, plants small.	11
	Pileus brownish, obscurely zonate, fading.	38. *L. paludinella.*
10.	Flesh thick, pileus soon dry.	34. *L. quieta.*
	Flesh thin, pileus shining-viscid when moist.	35. *L. nitida.*
11.	Umbo persisting dark, latex mild.	36. *L. oculata.*
	Umbo concolorous, margin crenate, milk acrid.	37. *L. minuscula.*

C

Latex becoming yellow, at least where in contact with the flesh

1.	Margin of young pileus with long tomentum.	2
	Margin of young pileus glabrous or minutely tomentose.	3
2.	Pileus white.	13. *L. resima.*
	Pileus yellowish, zonate, stem with bright pits.	12. *L. scrobiculata.*
3.	Latex mild.	68. *L. isabellina.*
	Latex slowly acrid or bitterish.	4
	Latex acrid.	6
4.	Pileus zonate, pinkish-buff to fulvous.	40. *L. theiogala.*
	Pileus azonate.	5
5.	Pileus whitish, not becoming perceptibly darker.	40. *L. theiogala.*
	Pileus whitish, then reddish-brown.	41. *L. colorascens.*
6.	Pileus umber-brown, subtomentose.	56. *L. subtomentosa.*
	Pileus some shade of yellow, glabrous.	7
7.	Pileus very viscid when moist.	8
	Pileus scarcely viscid, pallid, zoned with yellow spots.	42. *L. chrysorhea.*
8.	Pileus saffron-yellow, latex becoming yellow-cadmium.	15. *L. crocea.*
	Pileus maize-yellow, salmon-tinted, latex becoming sulphur-yellow.	16. *L. delicata.*

D

Latex becoming lilac or heliotrope, at least where in contact with the flesh

1.	Pileus covered with long tomentum, zonate.	14. *L. speciosa.*
	Pileus glabrous.	2
2.	Gray.	3
	Yellow.	4
3.	Azonate or faintly zoned, stem not spotted.	22. *L. lividorubescens.*
	Conspicuously zoned, stem spotted, plants large.	23. *L. maculata.*

4. Straw-colored, azonate, latex acrid. 20. *L. aspidea.*
Sulphur-yellow, zonate, latex bitter. 21. *L. aspideoides.*

E

Latex becoming salmon or reddish, at least where in contact with the flesh

1. Pileus glabrous, not spotted or zoned. 52. *L. plinthogala.*
Pileus velvety, seal-brown. 54. *L. ligniota.*

F

Latex becoming glaucous-green *

1. Pileus white, dry, latex very acrid. 6. *L. glaucescens.*

DESCRIPTIONS OF THE SPECIES, INCLUDING KEYS, ARRANGED BY GROUPS

1. PIPERATAE

Pileus without a pellicle and absolutely dry, glabrous or tomentose, flesh firm; plants for the most part large; gills not becoming darker with age nor pruinose; latex very acrid, white, unchanging except in *Lactaria glaucescens*, in which it dries glaucous-green.

In one species, *Lactaria deceptiva*, the margin is very involute, and is covered with a roll of tangled fine cottony tomentum as in the *Torminosae*.

Synopsis of species

Latex white, unchanging.
Plants large.
Pileus glabrous.
Pileus thin; gills very close, about 1 mm. broad. 2. *L. pergamena.*
Pileus thick; gills dichotomously forking, 2 mm. broad. 1. *L. piperata.*
Pileus velvety-tomentose.
Gills distant. 3. *L. vellerea.*
Gills close. 4. *L. subvellerea.*
Pileus with a cottony roll on margin, surface glabrous or torn. 5. *L. deceptiva.*
Plants small, pileus up to 5 cm. broad; margin involute, minutely silky. 7. *L. involuta.*
Latex drying glaucous on broken flesh and gills. 6. *L. glaucescens.*

1. LACTARIA PIPERATA (L.) Pers. Tent. Disp. Meth. Fung. 64. 1797

Agaricus piperatus L. Sp. Pl. 1173. 1753; Fl. Suec. 373. 1745.
Not *Agaricus piperatus* α and β, L. Fl. Suec. 441. 1755.
Agaricus Listeri Withering, Nat. Arr. Brit. Pl. 4: 156. 1801. [Ed. 4.]

* See also B § I, 19, and B § II, 9.

Pileus fleshy, compact, convex-umbilicate, at length infundibuliform, white, azonate, dry, glabrous, 4–12 cm. or more in diameter, margin involute at first and naked, at length uplifted; gills white or creamy-white, forking dichotomously, close, more or less decurrent, arcuate at first, then extending upwards, only about 2 mm. broad; stem white, equal, dry, often pruinose, solid and firm, 2–8 cm. long, up to 2 cm. thick, flesh white, unchanging or becoming sordid; spores white, subglobose, nearly smooth, 8–9 μ; latex white, unchanging, very acrid, abundant. *Edible.*

HAB.: In oak woods or groves. July to October.

DISTRIB.: New York, *Peck*, *Earle*, *Burlingham 20*, 1905; Connecticut, *Underwood;* New Jersey, *Sterling;* Pennsylvania, *Mrs. Dallas;* Maryland, *Banning;* District of Columbia, *Murrill, 1403;* Virginia, 600 meters elevation, *Murrill 272* and *371;* North Carolina, *Burlingham;* South Carolina, *Ravenel;* Tennessee, 500 meters elevation, *Murrill 517 B;* Alabama, *Underwood;* Indiana, *G. W. Wilson;* Missouri, *Glatfelter 345.* It has also been reported from the following states: Maine (White); Vermont (Frost); Rhode Island (Bennett); Ohio (Morgan); Minnesota (Johnson); Wisconsin (Bundy); California (Harkness & Moore).

ILLUST.: Atkinson, Stud. Am. Fungi, *f. 119;* Banning, Folio Md. Fungi, *pl. 83;* Barla, Champ. Nice, *pl. 22. f. 1–5;* Bel. Champ. Tarn. *pl. 22;* Bern. Champ. Roch. *pl. 37. f. 2;* Bolt. Geschichte, *pl. 21;* Boyer, Champ. Comest. et Vén. Fr. *pl. 30;* Britz. Lact. *f. 24;* Bull. Herb. Fr. *pl. 200, Agaricus acris;* Cooke, Br. Fungi, *pl. 979;* Cordier, Champ. Fr. *pl. 28. f. 1;* Eng. & Prantl, Nat. Pflanzenfam. **1**[1**]: *f. 110B;* Fl. Dan. *pl. 1132;* Fries, Sverig. Svamp. *pl. 27;* Hahn, Der Pilz-Sammler, *f. 18*, ed. 2; Harzer, Pilze, *pl. 39;* Krombh. Abbild. *pl. 56. f. 1–4;* Lanzi, Fung. Mang. *pl. 54. f. 2 a, b, c;* Lorinser, Essb. und Gift. Schwäm. *pl. 9. f. 4;* McIlvaine, One Thous. Am. Fungi, *pl. 41. f. 1.;* Pat. Tab. Analyt. Fung. *pl. 119;* Paulet, Traité Champ. *pl. 68. f. 3–4;* Roumeg. Crypt. Illustr. *f. 144;* Rich. & Roze, Atl. Champ. *pl. 40. f. 5–8;* Schaeff. Fung. Bav. Icon. *pl. 83, Agaricus amarus;* Sicard, Hist. Nat. Champ. *pl. 44. f. 235;* White, Conn. Geol. and Nat. Hist. Surv. Bull. **3**: *pl. 9.*

EXSIC.: Ravenel, Fungi Caroliniani, fasc. 2, 5 *p. p.*; Roumeguère, Fungi Gallici *3819.*

DISTINGUISHING FIELD-MARKS: The glabrous, white pileus, the

close, dichotomously forking, rather narrow gills, and the thick flesh. Usually the latex remains entirely white, and the flesh is odorless.

In North Carolina I found plants agreeing in all other essentials with *Lactaria piperata* except that the latex dried a pale-yellowish, and the fresh plant when wet or when rubbed had the odor of crushed blackberries, and the gills were slightly less crowded. This can scarcely represent more than a form of the species and on account of the odor, which is the distinguishing characteristic, I will refer to it as form **fragrans.** It is *no. 79*, 1907, of my North Carolina plants. Gillet recognizes a form *amara*, in which the milk becomes yellowish in drying, but the plant is odorless.

In *Species Plantarum* 1173. 1753, Linnaeus gives as synonyms of his *piperatus* the following: *Amanita piperata alba*, Dill. Giss. 179; *Fungus piperatus albus acris*, Mich. Gen. 141; Haller, 34. n. 1; and *Fungus albus acris*, C. Bauhin 371. No mention was made by any of these writers of incarnate gills, Micheli describing his *piperatus* under *unicolores albi*, and Haller under gills white. Since the *piperati* referred to by Linnaeus are all described as white, and no mention is made of zones or tomentose covering, this character of the gills seems scarcely sufficient evidence to indicate that Linnaeus had in mind *Agaricus piperatus* var. *α* and *β*, Fl. Suec. 441. 1755, when he described *Agaricus piperatus* in Fl. Suec. 373. 1745, and Sp. Pl. 1173. 1753. If it were shown that the *Agaricus piperatus* L. Sp. Pl. 1173. 1753, were the same as *Agaricus piperatus* L. Fl. Suec. 441. 1755, var. *α* and *β*, then *Lactaria torminosa* (Schaeff.) Pers. would be the real *Lactaria piperata* and *Lactaria torminosa* would be reduced to a synonym. For, according to the present codes, *Agaricus piperatus* must be credited to Linnaeus whatever the type may prove to be, so there is no ground for crediting Scopoli with the name, and, furthermore, Scopoli gives *Agaricus piperatus* Sp. Pl. 1173 and Fl. Suec. 441. 1755 as synonyms of his own *piperatus*.

In conclusion, it seems most probable that the forms included under var. *α* and *β*, Fl. Suec. 441. 1755, were found later by Linnaeus and incorrectly referred by him to *Agaricus piperatus* as described in Sp. Pl. 1173. 1753, which was undoubtedly the esculent *fungus piperatus* of the ancient writers and the German "*Pfefferling*."

2. LACTARIA PERGAMENA (Swartz) Fr. Epicr. 340. 1838. [As *Lactarius.*]—Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 537. 1889

Agaricus pergamenus Swartz, Kongl. Sv. Vet.-Akad. Nya Handl. **30**: 90. 1809.

Pileus fleshy, pliant, thin, convex to plane or depressed, often irregular and eccentric, and usually flexuous, white to creamy-white when old, azonate, dry, glabrous, minutely wrinkled, 4–11 cm. broad; gills white, then straw-colored, very close, thin, forking, adnate, horizontal, very narrow (1 mm. broad); stem white, equal or tapering downwards, glabrous, smooth, stuffed, but firm; spores white, minutely echinulate, elliptical, 8 × 6 μ; flesh white; latex white, abundant, acrid. *Edible.*

HAB.: In dry oak woods. August, September.

DISTRIB.: New York, *Peck*, *Burlingham* (120 meters elevation); Vermont, *Frost;* Connecticut, *Earle;* Virginia, *Murrill;* North Carolina, 1,000 meters elevation, *Burlingham 39*, 1907; Alabama, *Earle;* Ohio, *Morgan*, *Dawson;* Tennessee, 500 meters elevation, *Murrill 517;* Mississippi, *Earle.*

ILLUST.: Batsch, Elench. Fung. *pl. 13. f. 59, a, b, c. Agaricus piperatus;* Britz. Lact. *f. 10;* Cooke, Br. Fungi, *pl. 978;* Gillet, Champ. Fr. *pl. 152* [*389*]*; Krombh. Abbild. *pl. 57. f. 1–6;* Lucand, Champ. Fr. *pl. 42.*

DISTINGUISHING FIELD-MARKS: This species is very closely related to *Lactaria piperata*, and is often confused with it. According to Fries it differs from *Lactaria piperata* in having a stuffed stem which at length becomes spongy, and is longer, tapers downwards, and is perfectly glabrous; in the thinner, pliant, elastic, often irregular and eccentric, and for the most part, flexuous pileus, which is at first convex and not umbilicate, then rather plane, and wrinkled in a peculiar manner; in the gills being adnate, very close and very narrow, always straight and plane, and soon becoming straw-colored. The latex is more abundant in the flesh than in the gills.

Lactaria pergamena is not so common as *Lactaria piperata.* The latex sometimes dries sulphury-white (*14. t. 2*).

* The plates in Gillet's Champ. Fr. were renumbered in 1890 and again in the final edition. In citation I have given the original number and in brackets the numbers which occur in the subsequent revisions.

3. LACTARIA VELLEREA (Fr.) Fr. Epicr. 340. 1838. [As *Lactarius.*]. — Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 538. 1889

Agaricus vellereus Fr. Syst. Myc. **1**: 76. 1821.

Pileus fleshy, thick, firm, convex-umbilicate, with inrolled, then extended margin, depressed in the center, whitish, tinged in places with grayish or yellowish, dry, minutely tomentose, 6–11 cm. broad; gills whitish, becoming cream-colored or yellowish, changing to brownish with injury, many forking near the stem, interveined, shorter gills often joining with longer, distant, appearing more so with age or in larger specimens, adnate to slightly decurrent, 2–5 mm. broad; stem whitish, tinged in places with yellow, equal or rounded at the base, pruinose-velvety, 3–4 cm. long, 18–25 mm. thick; flesh white at first, staining yellowish; spores white, globose to ovate or elliptical, with only a few scattering blunt spines, uniguttulate, 5–6 μ × 8 μ; latex white, acrid, unchanging, or if creamy soon becoming white again. Regarded as poisonous by some.

HAB.: Open deciduous woods. July, August, September.

DISTRIB.: New York, *Peck*, *Earle*, *Burlingham*, *Peck & Earle* (Long Island); Vermont, *Burlingham 49*, 1906; Maine, *White;* Connecticut, *Underwood*, *Hanmer 153;* New Jersey, *Earle;* Virginia, *Murrill 135;* North Carolina, 1000–1200 meters elevation, *Burlingham 101*, 1907; Tennessee, 300 meters elevation, *Murrill. 526;* South Carolina, *Ravenel;* Alabama, *Earle.*

ILLUST.: Barla, Champ. Nice, *pl. 22. f. 6–8;* Bres. Fung. Mang. *pl. 67;* Britz. Lact. *f. 26;* Bull. Herb. Fr. *pl. 538. f. G, H, N;* Cooke, Br. Fungi, *pl. 980;* Cordier, Champ. Fr. *pl. 28. f. 2;* Gillet, Champ. Fr. *pl. 153* [*400*]; Hahn, Der Pilz-Sammler, ed. 2. *pl. 4. f. 17;* Hussey, Illust. Br. Myc. **1**: *pl. 63;* Klotzsch, in Dietrich, Fl. Bor. *pl. 469;* Krombh. Abbild. *pl. 57. f. 10–13;* Lanzi, Fung. Mang. *pl. 54. f. 1;* Lorinser, Essb. und Gift. Schwäm. *pl. 9. f. 5;* Phoebus, Deutschl. Krypt. Giftgewächse, *pl. 4. f. 3, 4;* Rich. & Rose, Atl. Champ. *pl. 3a. f. 1–3;* Sicard, Hist. Nat. Champ. *pl. 45. f. 239;* Sowerby, Eng. Fungi, *pl. 104*, *Agaricus Listeri;* White, Conn. Geol. and Nat. Hist. Surv. Bull. **3**: *pl. 9.*

EXSIC.: * Ravenel, Fungi Caroliniani, fasc. 2, *5 p. p.;* Roumeguère, Fungi Gallici *3819.*

* In the Fungi Caroliniani Exsic. of Ravenel, fasc. 2, *no. 5* in the herbarium of the N. Y. Botanical Garden, there are two specimens of *L. vellerea* Fr. on the sheet with *L. piperata* (L.) Fr.

DISTINGUISHING FIELD-MARKS: *Lactaria vellerea* may be distinguished from *Lactaria piperata* (L.) Fr. by the short tomentum on the pileus. In typical forms this is dense and gives the surface a very velvety feeling, but it is sometimes less prominent. The gills also differ in being distant and they stain brownish where wounded, while the milk dries in gummy drops on the gills. The gills do not for the most part fork dichotomously as in *Lactaria piperata*, but the shorter ones anastomose with the longer ones. While the latex is practically unchangeable, it is noted by Earle as becoming cream-colored (herb. N. Y. Bot. Garden *789, 846*, 1906). Massee says the latex sometimes becomes pale-sulphur when the flesh is broken but soon changes to white.

Up to the time of Fries, this mushroom was confused with so-called *piperatus* forms. *Agaricus piperatus* described by Pollich (Fl. Pal. **3**: 289) in 1777, is very clearly *L. vellerea* of Fries. This is the only description prior to Fries which makes mention of the tomentose covering of the pileus. Sowerby figures it in 1797, then considering it to be the same as the mushroom described by Dr. Lister (Ray Cat. Plant. 123. 1677). Bulliard's *Agaricus acris pl. 538. f. G, H, N,* is undoubtedly *L. vellerea* Fr.

4. LACTARIA SUBVELLEREA Peck, Bull. Torrey Club **25**: 369. 1898. [As *Lactarius*]

Pileus fleshy, thin, convex, soon umbilicate, at length nearly infundibuliform, white, becoming tinged or spotted with yellowish, and when dried cinnamon-colored (*323. t. 1–4*), azonate, dry, covered with velvet-like tomentum, 7.5–15 cm. broad, margin at first and for some time very involute, at length spreading; gills white to pale cream-colored, staining amber-white (*12. t. 4*) where the latex dries, often forking, adnate or slightly decurrent, narrow; stem white, tapering slightly toward the base, dry, velvety-pubescent, firm, 1.8–2.8 cm. long, 1.2–2.5 cm. thick; flesh amber-white, odor faint; spores subglobose, smooth, 6–6. 5 μ × 6.5–7.5 μ, latex pale cream-colored or whitish, very acrid, usually abundant.

HAB.: On dry ground, mixed woods. July.

DISTRIB.: Alabama, *Earle* (type); North Carolina, *Burlingham* 7, 1907.

DISTINGUISHING FIELD-MARKS: This species differs from *L. vellerea*, to which it is closely related, in the narrow close gills, and in the finer velvety tomentum or pubescence covering the

pileus and the stem. The latex is cream-colored or dries yellowish on the gills. The change in color of the pileus and stem during drying is a marked characteristic.

The type specimens are in the herbarium of the N. Y. Botanical Garden. The specimen which I found in North Carolina has the gills a little more distant, but otherwise appears like the type. It occurred in oak-chestnut woods at an elevation of 1000 meters.

5. LACTARIA DECEPTIVA Peck, Ann. Rep. N. Y. St. Bot. **38**: 125. 1885. [As *Lactarius*.] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**[1]*******: 216. 1898.

Pileus fleshy, firm, convex-umbilicate, then expanded and centrally depressed or somewhat infundibuliform, white or whitish, dry, glabrous at first, becoming torn into fibers and cracked as the pileus matures, 5–15 cm. broad, margin involute at first and covered with a dense soft cottony tomentum which fills in the space between the margin and the stem, then spreading or elevated and more or less fibrillose; gills whitish or cream-colored, some forking, somewhat distant, adnate or decurrent, rather broad; stem white, nearly equal, pruinose-pubescent, solid, 2–8 cm. long, 10–40 mm. thick; flesh white; spores white, globose to elliptical, echinulate, 8–9 μ × 9–12 μ; latex white, unchanging, acrid. *Edible.*

HAB.: On the ground in woods, especially near hemlock trees, rarely in oak-chestnut woods. July, August, and September.

DISTRIB.: New York, *Peck, Shear, Jackson, Burlingham;* Maine, *White;* Vermont, *Burlingham 21*, 1906; Massachusetts, *Vail;* Connecticut, *Underwood & Earle, Hammer 682;* Pennsylvania, *Herbst;* Virginia, *Murrill 80;* North Carolina, 1000 to 1675 meters elevation, *Burlingham 56*, 1907; Alabama, *Earle;* Ontario, *Guillet.*

ILLUST.: Atkinson, Stud. Am. Fungi, *f. 120, 121, Lactarius resimus;* White, Conn. Geol. and Nat. Hist. Surv. Bull. **3**: *pl. 8.*

EXSIC.: Shear, New York State Fungi *19.*

DISTINGUISHING FIELD-MARKS: This species has been much confused with *L. vellerea* Fr. and *L. piperata* (L.) Fr., but differs decidedly from both. The mature glabrous form of *L. deceptiva* resembles the latter in general appearance, but the texture of the pileus, the broader and more distant gills, and the larger more echinulate spores distinguish it from that species. The pileus of *L. vellerea* is covered over the entire surface with a short velvety tomentum, while the center of *L. deceptiva* is practically glabrous

in the young state, and the margin is covered with cottony fibers forming a soft roll-like veil. The surface for some distance toward the center has the texture and the feeling of chamois-skin. In very wet weather the cottony roll on the margin sometimes feels slightly slippery.

6. LACTARIA GLAUCESCENS Crossl. Naturalist **1900**: 5. 3 Ja 1900. [As *Lactarius*]

Pileus fleshy, firm, thick, convex-umbilicate, then infundibuliform, white, becoming stained or spotted with yellowish-buff, dry, glabrous, 4–9 cm. broad, margin involute at first, even, naked; gills maize-yellow (*36. t. 1–4*) at first, becoming white as the pileus expands, staining glaucous-green (*253. t. 1.*) where the latex dries, forked, very close, adnate, 1–1.5 mm. wide; stem white, tapering downwards or sometimes nearly equal, solid, firm, 3–9 cm. long, 1.5 cm. thick at the base to 2 cm. at the apex; flesh whitish, staining glaucous-green where the latex dries; spores white, globose, minutely and sparsely echinulate, 5.5–7 μ, cystidia terete-clavate, 40–60 μ × 7–8 μ; latex white, drying glaucous-green on the flesh and gills, very acrid, abundant. (FIGURE 1.)

FIGURE 1. *Lactaria glaucescens* Crossl. *No. 17*, 1907.

HAB.: On the ground in sandy loam or in vegetable soil, oak-chestnut woods. July and August.

DISTRIB.: North Carolina, 1000 meters elevation, *Burlingham 17*, 1907.

ILLUST.: Crossland, New and Crit. Brit. Fungi, Naturalist 1900: 10. *f. 1–3*.

DISTINGUISHING FIELD-MARKS: The gills are very narrow and so crowded when young that a space between them is scarcely visible, and while tinted dull-yellowish when young, they become white with age. The abundant white latex dries glaucous-green, which characteristic separates the species from all the other members of this group. It differs from *L. pergamena* also by the thick flesh of the pileus, and from *L. piperata* in its narrower and more crowded gills. It was abundant in the "Pink Beds," North Carolina, in rather dry oak-chestnut woods, during the latter part of July and August. It is probable that it grows elsewhere, but has been referred to *L. piperata*.

7. LACTARIA INVOLUTA Soppit; Cooke, Handb. Br. Fungi, ed. 2, 380. 1883. [As *Lactarius*]

Pileus fleshy, firm, convex, then plane or slightly depressed, white with pale-ochraceous tinge, dry, smooth, glabrous, 2–5 cm. broad, margin arched, involute, extreme edge minutely silky; gills white, sometimes forked, densely crowded, somewhat decurrent, about 1 mm. broad; stem white, equal, or thickened below, glabrous, smooth, solid, 2.5 cm. long, 6 mm. thick; spores white, pip-shaped, smooth, $5 \times 3\ \mu$ ($5 \times 7\ \mu$); latex white, unchanging, very acrid, not scanty.

HAB.: On the ground, in woods or in grassy places on the edge of woods. July.

DISTRIB.: Connecticut, *Hanmer 1479*; Alabama, *Underwood & Earle*.

ILLUST.: Cooke, Br. Fungi, *pl. 1194*.

DISTINGUISHING FIELD-MARKS: This differs from the other *Piperatae* forms in its small size, and in the minutely silky covering on the margin of the pileus. The gills are as closely crowded as in either *L. glaucescens* Crossl. or *L. pergamena* (Swartz) Fr. The minute pip-shaped or obliquely elliptical spores also distinguish it.

In the Hanmer specimen the spores vary much in size, and in this as well as in the Alabama specimens they run a little larger than noted by Cooke, although spores as small as in that also occur. The spores are really the final test in determining this species and care must be taken not to mistake for it small specimens of some of the other species.

II. RUSTICANAE

Pileus without a pellicle, as in the *Piperatae*, and never viscid, though in some species somewhat moist; color always dark, varying from gray to brown or reddish-brown, tinted with lilac, while in *Lactaria atroviridis* the color is dark-green; flesh compact; latex usually very acrid, white and unchanging, although the wounds sometimes change color.

Synopsis of species

Pileus glabrous, at least at first.	
Gray to brown with lilac tints.	
Gills thin.	**8.** *Lactaria rusticana.*
Gills thick, pileus becoming rivulose-squamulose.	*Lactaria flexuosa.**
Fuliginous to brownish-black.	*Lactaria plumbea.**
Pileus scabrous-hairy.	
Olivaceous-green.	**9.** *Lactaria atroviridis.*

8. **Lactaria rusticana** (Scop.)

Agaricus rusticanus Scop. Fl. Carn. **2**: 452. 1772.

Agaricus pyrogalus Bull. Herb. Fr. *pl. 529. f. 1.* 1791; Hist. Champ. **1**: 487. 1809.

Lactarius pyrogalus Fr. Epicr. 339. 1838.

Pileus fleshy, firm, broadly convex, then plane to somewhat depressed, gray to livid-gray or brownish-gray, darker in the center, zoned toward the margin, moist in wet weather, but not viscid, glabrous, 3.5–6.5 cm. broad, margin glabrous, inrolled, then arched in mature specimens; gills cream to ochroleucous, rarely forking, distant, adnate, up to 5 mm. broad; stem paler than the pileus, silver-gray, tinted with ochroleucous, nearly equal, sometimes tapering downwards, glabrous, smooth, compact, 3–5 cm. long, 6–10 or 16 mm. thick; flesh white, compact, thick, unchanging; spores white, globose to subglobose, echinulate, greenish-hyaline, 6–6.5 μ × 6–8 μ; cystidia transparent, 16–20 μ long, 5–10 μ at the base, abruptly tapering; latex white, unchanging, very acrid. *Poisonous.*

HAB.: On open grassy places in woods. July to October.

* European species, the occurrence of which in the United States is doubtful.

DISTRIB.: New York, *Peck, Burlingham;* Vermont, *Burlingham 14*, 1906; Ohio, *Dawson;* Maryland, *Banning.*

ILLUST.: Banning, Folio Md. Fungi, *pl. 86;* Bull. Herb. Fr. *pl. 529. f. 1;* Gillet, Champ. Fr. *pl. 52* [*162; 390*]; Hahn, Der Pilz-Sammler, *f. 21* (poor); Krombh. Abbild. *pl. 14. f. 1–9;* Lanzi, Fung. Mang. *pl. 55. f. 2. a, b, c, d*; Noulet & Dass. Champ. *pl. 19. f. A;* Pat. Tab. Analyt. Fung. *pl. 121;* Rich. & Roze, Atl. Champ. *pl. 37. f. 13–15* (poor); Sicard, Hist. Nat. Champ. *pl. 45. f. 240.*

DISTINGUISHING FIELD-MARKS: The nearly plane pileus, with the margin remaining deflexed, the gray or brownish-gray zonate surface, the absence of viscidity, and the distant rather yellowish gills. In color it resembles both *Lactaria circellata* Fr. and *Lactaria flexuosa* Fr., from the former of which it may be distinguished by the lack of viscidity, and from the latter by the persistently glabrous surface, the more regular margin, and the less distant gills.

9. LACTARIA ATROVIRIDIS Peck, Ann. Rep. N. Y. St. Mus. **42**: 119. 1889

Pileus fleshy, compact, nearly plane, soon depressed in the center, olivaceous, azonate, dry, scabrous-hairy, sometimes cracking into small areas, 6–10 cm. broad, margin involute, at length spreading to uplifted; gills whitish, becoming mottled with dark-green, especially where injured, sometimes forking near the stem, close, adnate to slightly decurrent, rather narrow; stem colored like the pileus or paler, spotted, equal, dry, glabrous, firm, soon hollow, 2–5 cm. long, 1–2 cm. thick; flesh white; spores creamy-white, subglobose, echinulate, 7–8 μ; latex white, unchanging, but staining the gills green after some time, acrid.

HAB.: Deciduous woods. July and August.

DISTRIB.: New York, *Peck;* Connecticut, *Underwood & Earle;* District of Columbia, *Murrill.*

DISTINGUISHING FIELD-MARKS: *Lactaria atroviridis* closely resembles *Lactaria turpis* (Weinm.) Fr., especially when dried, but in the fresh condition it may be distinguished from it by the absence of viscidity in wet weather, by its dark-green color, and by the change in color of the wounded gills.

The type specimens of this species are in the herbarium of the N. Y. State Museum at Albany. The species seems to be rare.

DOUBTFUL SPECIES

LACTARIA PLUMBEA (Bull.) Fr. Epicr. 339. 1838. [As *Lactarius.*]
— Schröter in Cohn, Krypt.-Fl. Schles. **3**: 536. 1889.

This species has been reported from New York by Peck; from Wisconsin by Bundy. The specimens referred to *Lactaria plumbea* by Peck differ from the typical form in color and in the presence of a tomentum in the fresh condition. It seems to me doubtful whether the New York specimens represent this species. They appear much like *L. glyciosma* but have no odor. Bundy's specimens are not preserved. The species is described in the Ann. Rep. N. Y. St. Mus. **38**: 127. 1885. A good figure of it may be found in Barla, Champ. Nice, *pl. 21. f. 1–5.* It is regarded as poisonous.

LACTARIA FLEXUOSA (Fr.) Fr. Epicr. 338. 1838. [As *Lactarius.*]
— Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 536. 1889

This European species has been reported from North Carolina by Schweinitz, from Vermont by Frost and by Burlingham. The specimens which I assigned to this species do not correspond closely enough to specimens which I have since received from Romell, to justify citing them as this species. The Frost and Schweinitz specimens are not preserved. The species is well figured by Cooke, Br. Fungi, *pl. 992.*

III. TORMINOSAE

Plants rather large, but the flesh not so compact as in the *Piperatae*, and the pileus viscid when wet; margin of the pileus inrolled at first and covered with long coarse tomentum, which may be persistent or fugacious. The latex varies from intensely acrid in *L. torminosa* to acrid in *L. speciosa.*

Synopsis of species

Latex white, becoming yellow.	
Pileus white, azonate.	13. *Lactaria resima.*
Pileus yellowish, zonate to subzonate.	12. *Lactaria scrobiculata.*
Latex white, wounds becoming heliotrope.	14. *Lactaria speciosa.*
Latex white, unchanging.	
Marginal tomentum persistent.	
Pileus zonate, some shade of yellow.	10. *Lactaria torminosa.*
Pileus azonate.	
White to flesh-colored tinged with fuscous.	11. *Lactaria cilicioides.**

* The latex sometimes very slowly turns yellowish.

Marginal tomentum fugacious.

Pileus white, zoned or spotted with red. *Lactaria sanguinalis.**

10. LACTARIA TORMINOSA (Schaeff.) Pers. Tent. Disp. Meth. Fung. 64. 1797

Agaricus torminosus Schaeff. Fung. Bav. Icon. **4**: 7 (index). 1774.

Lactarius villosus Clements, Bot. Surv. Neb. **4**: 20. 1896.

Pileus fleshy, convex, depressed in the center with the margin involute, finally nearly infundibuliform with the margin merely deflexed, pale pinkish-yellow or pale-ochroleucous or ochraceous tinged with incarnate, often zoned with deeper color, sometimes nearly white and azonate, viscid when wet, 4–10 cm. broad, center glabrous, margin persistently white-tomentose; gills whitish or cream-yellow tinged with pale-incarnate, some forking near the stem, close, decurrent, thin, 5 mm. broad; stem paler than the pileus, sometimes faintly spotted with yellow, equal or tapering downwards, glabrous or pruinose, smooth, stuffed, becoming hollow, 3–7 cm. long, 2 cm. or less thick; flesh white, not changing color; spores white, broadly elliptical, echinulate, uniguttulate, hyaline, 8–10 μ × 6–8 μ; latex white, unchanging, very acrid. *Poisonous.*

HAB.: In deciduous or coniferous woods, in open or shady places. August and September.

DISTRIB.: New York, *Peck*, *Underwood;* Maine, *Murrill*, *White;* Vermont, *Burlingham 56*, 1906, *Burt;* Connecticut, *Underwood;* Alabama, *Earle;* North Carolina, 1000 meters elevation, *Burlingham;* Colorado, 2900 meters elevation, *Clements;* Nebraska, *Clements.*

ILLUST.: Atkinson, Stud. Am. Fungi, *f. 118;* Barla, Champ. Nice, *pl. 18. f. 7–10;* Britz. Lact. *f. 5;* Bull. Herb. Fr. *pl. 529. f. 2, Agaricus Necator;* Cordier, Champ. Fr. *pl. 27. f. 1;* Eng. & Prantl, Nat. Pflanzenfam. **1**[1]**: *f. 110 c;* Fl. Dan. *pl. 1068;* Fr. Sverig. Svamp. *pl. 28;* Gauthier, Champ. *pl. 11. f. 2* (poor); Gillet, Champ. Fr. *pl. 51* [*159; 395*]; Hahn, Der Pilz-Sammler, ed. 2. *f. 23;* Harzer, Pilze, *pl. 11;* Krombh. Abbild. *pl. 13. f. 15–23;* Lanzi, Fung. Mang. *pl. 57. f. 2. a, b, c, d;* L'Escluse, Études et Commentaires, *pl. 64. f. 1;* Lorinser, Essb. und Gift. Schwäm. *pl. 8. f. 8;* Lucand, Champ. Fr. *pl. 972;* Noulet & Dass. Champ. *pl. 17. f. B;* Phoebus, Deutschl. Krypt. Gift-

* European species, the occurrence of which in the United States is doubtful.

gewächse, *pl. 5*; Rich. & Roze, Atl. Champ. *pl. 37. f. 1–6*; Schaeff. Fung. Bav. Icon. *pl. 12*; Sicard, Hist. Nat. Champ. *pl. 43. f. 232*; Sv. Bot. *pl. 184*; Sowerby, Eng. Fungi, *pl. 103*; Venturi, Stud. Micol. *pl. 6. f. 53, 54.*

EXSIC.: Clements, Cryptogamae Formationum Coloradensium *364*; Herpell, Sammlung präparirter Hutpilze *46*; Karsten, Fungi Fennici, *508*; Sydow, Mycotheca Marchica *1504.*

DISTINGUISHING FIELD-MARKS: The large size, the persistent long whitish tomentum on the margin, and the unchanging white latex. The color of the pileus is some shade of yellow, sometimes tinted with incarnate, and it is usually zoned. The tomentum often extends from the margin midway to the center of the pileus. Occasionally, nearly white azonate forms occur.

After comparing the type specimens of *Lactarius villosus* Clements with both American and European specimens of *Lactaria torminosa* (Schaeff.) Pers. I have concluded that it is without question identical with the latter species. The spore-measurements run somewhat larger than indicated by Clements and the stem becomes hollow as shown both in the specimens and in the photograph accompanying the sheet in the Crypt. Format. Coloradensium.

This species is the *Agaricus piperatus* var. α L. Fl. Suec. 441. 1755, but not the *Agaricus piperatus* L. Sp. Pl. 1173. 1753, which from the synonyms given by Linnaeus is plainly the same as *Lactaria piperata* of Fries. In Monogr. Suec. **2**: 153, Fries describes the stem as "*subtiliter adpresse tomentosus l. glabratus*," and Massee and Stevenson have followed Fries' description in this particular; but in all specimens which I have examined the stem appears to the naked eye as merely pruinose, and even with the aid of a lens it can scarcely be described as tomentose.

11. LACTARIA CILICIOIDES (Fr.) Fr. Epicr. 334. 1838. [As *Lactarius.*]—Hennings, in Eng. & Prantl, Nat. Pflanzenfam. I^{1}**: 218. 1898

Agaricus tomentosus Otto, Versuch Agar. 74. 1816. Not *Agaricus tomentosus* Bull. Herb. Fr. *pl. 138.* 1782.

Agaricus cilicioides Fr. Syst. Myc. **1**: 63. 1821.

Pileus fleshy, not very compact, convex, becoming plane with

the center depressed, sometimes nearly infundibuliform, pale-incarnate tinged with fuscous, azonate, viscid when wet, entirely covered with matted tomentum, 5–10 cm. broad, margin involute, fibrillose-woolly; gills white to yellowish, forking, close, decurrent, rather narrow; stem whitish, sordid, never spotted or scrobiculate, equal, pruinose-silky when viewed with a lens, firm, stuffed, at length somewhat hollow, 5–7.5 cm. long, up to 2.5 cm. thick; flesh yellowish-white; spores white, minutely echinulate, broadly elliptical, 8 μ × 6–7 μ; latex white or pale yellowish-white, acrid, not abundant, sometimes becoming more yellowish when exposed to the air.

HAB.: "Woods and open places, especially near pine trees," Peck. September and October.

DISTRIB.: New York, *Peck*. It has also been reported from Maine by Ricker, and from Ohio by Morgan.

ILLUST.: Britz. Lact. *f. 2;* Cooke, Br. Fungi, *pl. 973;* Schaeff. Fung. Bav. Icon. *pl. 228, Agaricus crinitus.*

DISTINGUISHING FIELD-MARKS: This species may be distinguished from *Lactaria torminosa*, to which it is closely related, by the shorter and more matted tomentum covering the entire pileus, by the paler or duller-colored azonate pileus, and by the less abundant latex. At the margin of the pileus the tomentum becomes somewhat longer. It is finer than the tomentum on the margin of *Lactaria torminosa.*

Agaricus intermedius Krombh. *pl. 58. f. 11–13* has been considered a variety of *L. cilicioides*, but it seems to be more nearly *Lactaria scrobiculata* Scop. Massee, however, describes it as a distinct species. Krombholtz describes an *Agaricus tomentosus pl. 40. f.17, 18* * as synonymous with *Agaricus tomentosus* of Otto, and Massee and Cooke have followed Krombholtz, but there does not seem to me to be sufficient evidence that Krombholtz' species is the same as that of Otto, while Otto's description agrees well with *Agaricus cilicioides* Fr. The specific name given either by Schaeffer or Otto was a homonym, hence *cilicioides* stands as the specific name.

12. LACTARIA SCROBICULATA (Scop.) Fr. Epicr. 334. 1838. [As *Lactarius.*]—Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 341. 1889

Agaricus scrobiculatus Scop. Fl. Carn. **2**: 450. 1772.

Pileus fleshy, convex, soon depressed in the center, at length

* *Fig. 17* is lacking, and *f. 18* shows no tomentum.

infundibuliform, yellowish to ochraceous or even reddish-yellow, zoneless, or subzonate or conspicuously zonate, viscid when moist, 6–15 cm. broad, margin at first involute and tomentose, then spreading and plane or upturned and nearly or quite naked; gills whitish or pale-yellowish, sometimes forking close to the stem, crowded, adnate or slightly decurrent, thin; stem of the same color as the pileus or paler, with brighter-colored elliptical or orbicular scrobiculate spots, equal, glabrous, hollow, 3–7 cm. long, 1–2 cm. thick; spores white, minutely echinulate, 6.5–7 μ × 8–10 μ; latex white, quickly changing to sulphur-yellow, acrid. *Suspicious.*

HAB.: In moist woods. July to November.

DISTRIB.: New York, *Peck;* Vermont, *Frost;* Connecticut, *Earle;* Alabama, *Earle.*

ILLUST.: Barla, Champ. Nice, *pl. 18. f. 3–6;* Britz. Lact. *f. 1;* Cooke, Br. Fungi, *pl. 971;* Gillet, Champ. Fr. *pl. 154* [*392*]; Hahn, Der Pilze-Sammler, ed. 2. *f. 24;* Krombh. Abbild. *pl. 58. f. 1–6;* Lorinser, Essb. und Gift. Schwäm. *pl. 9. f. 6;* Lucand, Champ. Fr. *pl. 971;* Pat. Tab. Analyt. *pl. 409;* Schaeff. Fung. Bav. Icon. *pl. 227.*

DISTINGUISHING FIELD-MARKS: The yellowish, more or less zonate pileus, the coarse rather conspicuous tomentum on the margin of the young pileus, the bright-colored scrobiculate spots on the stem, and the rapid change in the color of the latex from white to sulphur-yellow. The plants are large and the margin becomes glabrous in the mature plant.

Lactaria scrobiculata is commonly described by European writers as azonate. But Fries in Monogr. **2**: 153, says "*vulgo azonus, interdum vero conspiciuntur zonae.*" Massee and Stevenson also describe it as sometimes zonate. The Alabama specimens are conspicuously zonate in the dried state, while the Connecticut specimens are zonate or subzonate. When the plants are growing in the open they fade more or less and this may account in part for the difference in zonation.

13. LACTARIA RESIMA (Fr.) Fr. Epicr. 336. 1838. [As *Lactarius.*] — Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 542. 1889

Agaricus resimus Fr. Hym. Eur. 472. 1821.

Pileus fleshy, firm, deeply umbilicate with the margin involute, at length infundibuliform with the margin arched or spreading, whitish, soon faintly tinged with yellow, darker in the center,

azonate, viscid when wet, glabrous except the extreme margin, which is white-tomentose, at length entirely glabrous, 8 cm. or more broad; gills whitish or pale-cream, a few forking near the stem, close, decurrent, about 4 mm. broad; stem whitish, spotted with cream or dull-yellow, equal, glabrous, or pruinose at the top, stuffed, becoming hollow, 3.5 cm. long, 2.5 cm. thick; flesh white, odor rather strong when fresh and persisting for a time; spores white, globular to elliptical, echinulate, 5–7 μ × 7–9 μ; latex instantly changing to sulphur-yellow, acrid.

HAB.: In woods, chiefly in mountainous regions.

DISTRIB.: Vermont, *Burlingham 110*, 1906.

ILLUST.: Fr. Icon. *pl. 169. f. 1.*

DISTINGUISHING FIELD-MARKS: The whitish lily-shaped azonate pileus with a fringe-like white tomentum on the extreme margin, and the very rapid change in the color of the latex from white to sulphur-yellow. In the mature plant the tomentum is often lacking. The specimen found in Vermont was growing under a small spruce on the edge of a wood in a somewhat mountainous district. Near the edge of the pileus were four or five faint ridges or corrugations running parallel to the margin.

In Monogr. 2: 152, Fries says of the stem "*sub lente pube tenuissima vix perceptibili tectus.*" In other places the stem is described as villous, but the statement in the Monograph is the more accurate. Our specimen, however was simply pruinose, and it is probable that the scarcely perceptible down mentioned by Fries was little more than a pruinosity, although there might be a variation in the nature of the covering under different environmental conditions.

14. **Lactaria speciosa** sp. nov.

Pileus fleshy, rather firm, convex-umbilicate, becoming depressed in the center with the margin arched, whitish, approaching honey-color or maize-yellow in the center and zoned with honey-color (*35. t. 3*), or maize-yellow (*36. t. 4*), viscid when wet, covered with long honey-colored tomentum arranged in concentric lines corresponding to the zones, 5–8 cm. broad, margin involute at first, at length spreading; gills white, becoming pale maize-yellow with age, staining heliotrope where injured, seldom forking, not very close, very slightly decurrent, 5–8 mm. broad; stem tinted with honey-yellow, with elliptical spots of flavous, sometimes scrobiculate, staining heliotrope where handled, equal, viscid

FIGURE 2. *Lactaria speciosa* Burl. *No. 40*, 1907.

when wet, sometimes slightly tomentose at the base, stuffed, becoming hollow, 2.5–7 cm. long, 1–1.5 cm. thick; flesh white, staining heliotrope where wounded, odor none; spores white, elliptical, strongly echinulate, 8–8.5 μ × 9.5–10 μ; latex white, not plainly changing, but staining the flesh and gills heliotrope (*188. t. 1*), mild to slightly acrid, abundant in young plants, scanty in old ones. (FIGURE 2.)

HAB.: In oak woods, sandy soil, oak-chestnut woods, frequently by wood-roads, in dry as well as wet weather. August and September.

DISTRIB.: "Pink Beds," North Carolina, 1000 to 1200 meters elevation, *Burlingham 40*, 1907 (type); Tennessee, 400 meters elevation, *Murrill;* Virginia, 670 meters elevation, *Murrill.*

DISTINGUISHING FIELD-MARKS: This species is readily recognized by the pallid pileus and the honey-colored tomentum and zones, together with the heliotrope color which injured parts assume. It was found abundantly during August in dry weather and in dry soil. The pileus is always zonate, the stem not at all or only slightly scrobiculate and the latex only slightly acrid. The tomentum is darker at the tips of the hairs, which become matted together in small clusters, thus standing out more prominently against the paler color of the pileus.

Lactaria speciosa is plainly not a degenerate form of *Lactaria scrobiculata* Fr. and the figure of *Lactaria repraesentanea* Britz. does not resemble this species and there is nothing in his brief description which would warrant considering the two species the same. Specimens of *Lactaria repraesentanea* Britz. presented to the N. Y. Botanical Garden by Romell differ from the type specimens of *Lactaria speciosa* in being glabrous except near the margin, azonate, and deeper- or brighter-yellow in color, while the spores are smaller and much less echinulate.

DOUBTFUL SPECIES

LACTARIA REGALIS Peck, Ann. Rep. N. Y. St. Mus. **26**: 64. 1874.

[As *Lactarius*]

The type specimens of this species differ from *L. resima* Fr. only in the glabrous margin, and it is uncertain whether the specimens represent a distinct species or whether they should be classed with *L. resima.* The margin of this latter species is at length gla-

brous and the stem is practically glabrous from the first. Although the type specimens of *L. regalis* do not show any very young plants, some of them seem to be young enough to have retained the tomentum on the margin. Since, however, only the type collection is known, I prefer to leave the species in doubt until further collections can be made.

LACTARIA SANGUINALIS (Batsch) Schröt. [*Lactarius controversus* Fr.]

This species has been reported from California by Harkness & Moore, but the specimens from which the determination was made were not preserved. The species is described in McIlvaine's One Thousand Am. Fungi, 164. 1902, and is well figured by Batsch, Elench. Fung. *pl. 36. f. 201*; by Fries, Sverig. Svamp. *pl. 29*; by Cooke, Br. Fungi, *pl. 1003*; and by Gillet, Champ. Fr. *pl. 160* [*381*]. *Edible.*

LACTARIA PUBESCENS (Fr.) Fr. This species was reported from New York by Peck (Ann. Rep. N. Y. St. Mus. **31**: 31. 1879), but was ommitted from his list of *Lactariae* in the 38th Report, 1885.

IV. CROCEAE

Pileus very viscid when young or in wet weather, the margin involute at first and covered with a short tomentum, some shade of yellow, zonate, plants large, flesh rather compact; gills darker with age, and more or less pruinose; latex acrid, white, changing to yellow.

Synopsis of species

Pileus maize-yellow tinted with yellowish-salmon, latex becoming sulphur-yellow.
16. *L. delicata*

Pileus saffron-yellow to orange-cadmium, latex becoming yellow-cadmium.
15. *L. crocea*

15. Lactaria crocea sp. nov.

Pileus fleshy, brittle, broadly convex-umbilicate with the margin involute, then expanding, depressed in the center with the margin deflexed, saffron-yellow to orange-cadmium (*49*), subzonate, expallent, very viscid when moist, glabrous, 5–10 cm. broad, margin involute and pruinose-downy at first, then glabrous; gills pallid, then honey-yellow (*35*), and at length yellowish-buff (*310. t. 1*), becoming cadmium (*47. t. 1*) where cut or bruised, seldom forking, not close, adnate, 5–6 mm. broad; stem of the same color as the pileus but paler, spotted, equal, glabrous or sometimes tomentose

FIGURE 3. *Lactaria crocea* Burl. *No. 48*, 1907.

at the extreme base, stuffed, becoming hollow, stout, 5 cm. long, up to 16 mm. thick; flesh whitish, staining yellow-cadmium where cut, odor none; spores yellowish, broadly elliptical, echinulate, 7 μ × 8–8.5 μ; latex white, scanty, slowly becoming yellow-cadmium, and staining the gills and flesh, acrid. (FIGURE 3.)

HAB.: In oak and chestnut woods, growing from vegetable mold and dead leaves. August and September.

DISTRIB.: North Carolina, 1000 meters elevation, *Burlingham 48*, 1907 (type); Virginia, *Murrill*.

DISTINGUISHING FIELD-MARKS: The beautiful orange-cadmium color of the viscid pileus and stem, and the paler, rather distant gills, which become yellow-cadmium where wounded. The zones are sometimes very distinct, but more often obscure, especially in old age. The latex is scanty and the change in color is detected mostly by the change in the color of the wounded gills and flesh. The wounds never become greenish as in *Lactaria deliciosa*. The much deeper color of the plant, the more

FIGURE 4. *Lactaria deliciosa* Burl. *No. 72*, 1907.

viscid pileus, and the more distant gills separate this species from *Lactaria chrysorhea* and *Lactaria theiogala*.

16. **Lactaria delicata** sp. nov.

Pileus fleshy, firm, convex-umbilicate, at length nearly infundibuliform, maize-yellow (*36. t. 3*), tinted in the center with yellowish-salmon (*65*), faintly but decidedly zonate, viscid and covered with gluten when wet, glabrous, 8–12 cm. broad, margin involute at first and covered with coarse short tomentum, then merely deflexed and glabrous; gills whitish, becoming maize-yellow with age, some forking near the stem, close, slightly decurrent, 5–7 mm. broad; stem whitish to maize-yellow tinted with yellowish salmon, more or less scrobiculate-spotted, spots of the same color as the rest of the stem or duller, equal or tapering downwards, glabrous, stuffed, becoming hollow, 4–5 cm. long, 1.5–2.5 cm. thick; flesh white, odor strong; spores tinted yellowish-salmon in mass, subglobose, echinulate, 7–8 μ; latex white, becoming sulphur-yellow, acrid, scanty. (FIGURE 4.)

HAB.: In sandy loam and dense shade, oak and chestnut woods. July and August.

DISTRIB.: "Pink Beds," North Carolina, 1000 meters elevation, *Burlingham*.

DISTINGUISHING FIELD-MARKS: The large size, the delicate yellowish-salmon tint over nearly the whole pileus, the faint nearly concolorous zones, the short tomentum on the margin of the immature pileus, the rather persistent viscidity, the lily shape of the mature pileus, and the change in the color of the latex.

This species may be distinguished from *Lactaria scrobiculata* by the less conspicuous tomentum on the margin of the pileus, the dull color of the less prominent scrobiculate spots on the stem, the yellowish spores, and the change in the color of the gills. It differs from *Lactaria theiogala* in color, in the greater viscidity of the pileus, the presence of short tomentum on the margin of the young pileus, the stouter character of the plant, the more infundibuliform pileus, and in the scanty, more acrid milk. The type specimens are in the herbarium of the N. Y. Botanical Garden.

V. AGGLUTINATAE

Pileus very viscid when young or in wet weather, margin involute at first and covered with a short tomentum, color from white to buff and umber with greenish tinge, becoming deeper in drying,

FIGURE 5. *Lactaria agglutinata* Burl. *No. 59*, 1907.

flesh rather firm, plants medium-sized to large; gills becoming deeper in color with age and more or less pruinose; latex acrid, white, unchanging.

Synopsis of species

Pileus whitish.	
Zonate, sparsely covered with coarse, short tomentum.	18. *L. lanuginosa.*
Azonate, glabrous.	*L. subinsulsa.**
Pileus buff, papillate when wet, squamulose when dry.	17. *L. agglutinata.*
Pileus olivaceous-umber, blackening in drying.	19. *L. turpis.*
Pileus grayish-green, zonate, not blackening.	*L. blennia.*†

17. **Lactaria agglutinata** sp. nov.

Pileus convex-umbilicate, then depressed in the center with the margin uplifted, at length infundibuliform, buff (*309. t. 4*), fading to buff (*310*) when mature, slightly zonate when young, scarcely so when older, slimy-viscid when wet, with subrugose elevations or papillae showing through the gluten, appearing squamulose to squarrulose when dry, 6–10 cm. broad, margin involute and minutely pubescent at first, the pubescence becoming less noticeable as the margin unfolds; gills yellowish-buff (*310. t. 1*), some forking near the stem, close, slightly decurrent, 2–4 mm. broad; stem of the same color as the pileus or paler, sometimes spotted, equal or tapering downwards, viscid when wet, glabrous, firm as though solid, becoming spongy to hollow, 2.5–4 cm. long, 1–1.5 cm. thick; spores creamy-white in mass (*10. t. 1, 2*), subglobose, echinulate, 7–8 μ; flesh white, odor somewhat like raw pumpkin; latex white, unchanging, acrid. (FIGURE 5.)

HAB.: Among dead leaves, in rather sandy soil, oak-chestnut woods, frequently under the flowering dogwood. August and September.

DISTRIB.: "Pink Beds," North Carolina, 1000 meters elevation, *Burlingham 59*, 1907.

DISTINGUISHING FIELD-MARKS: The medium size, buff color, and the papilliform and rugose elevations showing through thick, glistening gluten when wet, and the squamulose appearance of the pileus when dry. One peculiarity of the pileus is that if it becomes wet again after having dried, the squamules swell up and the surface appears papilliform and rugulose as at first.

This species seems to be quite distinct. While resembling the *Triviales* in the very viscid character of the pileus, it also approaches

* Doubtful species.

† European species, the occurrence of which in the United States is doubtful.

the *Torminosae* in the minutely tomentose condition of the margin of the young pileus. The gills become somewhat pruinose in the mature plant. While not abundant, the species was found several times during August and September, in as many different places.

FIGURE 6. *Lactaria lanuginosa* Burl. *No. 67, 1907.*

18. **Lactaria lanuginosa** sp. nov.

Pileus fleshy, firm, convex-umbilicate, then expanding and depressed in the center, whitish to yellowish-flesh (*68*), zoned especially toward the margin, where the zones are close and narrow, viscid, sparsely covered with agglutinated short white coarse tomentum, 7–8 cm. broad, margin involute at first and the extreme

edge covered with fine short tomentum, at length glabrous and upturned; gills whitish, at length maize-yellow (*36. t. 3*) to yellowish-buff (*310. t. 2*), seldom forking, close, slightly decurrent, 3–5 mm. broad; stem white, becoming yellowish-buff spotted more or less with darker, equal or tapering downwards, viscid when young or wet, minutely pubescent to hairy tomentose, then nearly glabrous, firm, stuffed, then hollow, 3 cm. long, 1–2 cm. thick; flesh white, unchanging, odor rather strong; spores white, nearly globose, echinulate, 6–7 μ; latex white, unchanging, scanty, astringent, not very acrid. (FIGURE 6.)

HAB.: Among dead leaves under oak, maples, alder, and *Rhododendron.* August and September.

DISTRIB.: North Carolina, *Burlingham.*

DISTINGUISHING FIELD-MARKS: The large, whitish, zonate pileus, covered with short sparse, agglutinated tomentum. The zones seem to be concentric translucent rings, which appear cream-colored in contrast with the opaque white of the remainder of the pileus. The tomentum is more noticeable when the viscidity has disappeared. In the dried plant the rings are conspicuous and bright-colored.

I found this species in the "Pink Beds," North Carolina, five times during August and September. It seems to be quite distinct from any other species. The type specimens, *no. 67*, 1907, are in the herbarium of the N. Y. Botanical Garden.

19. LACTARIA TURPIS (Weinm.) Fr. Epicr. 335. 1838. [As *Lactarius*]

Agaricus Necator Pers. Syn. Fung. 435. 1801. Not *Agaricus Necator* Bull. Herb. Fr. *pl. 14; pl. 529. f. 2.* 1780.

Agaricus turpis Weinm. Sylloge Plant. Nov. **2**: 85. 1828.

Lactarius sordidus Peck, Ann. Rep. N. Y. St. Mus. **23**: 119. 1872.*

Pileus fleshy, firm, thick, convex-umbilicate, then plane to depressed in the center, yellowish-brown or umber, with olivaceous tinge, darker in the center, azonate, slimy-viscid in wet weather, glabrous or agglutinated-fibrous, 6–12 cm. broad, margin involute at first and yellow-villose, then glabrous; gills cream-colored, then darker yellow, becoming nearly black where bruised, then ash-colored from the spores, many forking near the stem, close, somewhat decurrent, 3–4 mm. broad; stem of the same color as the pileus, equal or slightly smaller at the base, viscid when wet,

* Report of Botanist published in advance.

glabrous, smooth or somewhat scrobiculate, or sometimes merely spotted, spots becoming nearly black in dried specimens, firm, stuffed, occasionally becoming hollow when old, usually 3–4 cm. long, 1.5–2.5 cm. thick ; flesh whitish, odor slight ; spores white, globose to subglobose, echinulate, 6.5–8 μ ; latex white, unchanging, acrid. Possibly edible.

HAB. : On the ground in mixed woods, often near fir or spruce trees. August and September.

DISTRIB. : New York, *Peck ;* Vermont, *Jones, Burlingham ;* Maine, *White ;* Connecticut, *Hanmer ;* Ohio, *Beardslee ;* it was also reported from North Carolina by Schweinitz.

ILLUST. : Cooke, Br. Fungi, *pl. 987 ;* Fl. Dan. *pl. 1913 ;* Fr. Sverig. Svamp. *pl. 60 ;* Gillet, Champ. Fr. *pl. 158* [*397*] ; Hahn, Der Pilz-Sammler, ed. 2. *f. 22 ;* Harzer, Pilze, *pl. 60 ;* Krombh. Abbild. *pl. 69. f. 1–6 ;* Lorinser, Essb. und Gift. Schwäm. *pl. 9. f. 2 ;* Lucand, Champ. Fr. *pl. 41 ;* Phoebus, Deutschl. Krypt. Giftgewächse, *pl. 6. f. 1–3 ;* Roumeg. Crypt. Illustr. *f. 120.*

EXSIC. : Karsten, Fungi Fennici *306 ;* Sydow, Mycotheca Marchica *1009.*

DISTINGUISHING FIELD-MARKS : The yellowish-brown or olivaceous color of young plants and the blackish color of mature plants, the slimy condition of the whole mushroom in wet weather, the blackening of the gills with injury or in drying, and in many cases the grayish color due to the presence of the spores. The pileus may be covered with villose fibers which are closely stuck to the surface, and are not easily distinguishable, or it may be practically glabrous. The yellow down or villosity on the margin disappears in the mature plant, and is at no time conspicuous.

I have compared the type specimens of *Lactarius sordidus* Peck with European specimens of *Lactaria turpis* and have not been able to detect any specific difference. Some of the European forms show the stem to be slightly spotted, and some of the specimens of *L. sordidus* have slightly scrobiculate spots on the stem. These spots become more prominent in drying.

DOUBTFUL SPECIES

LACTARIA SUBINSULSA Peck, Ann. Rep. N. Y. St. Mus. **43**: 19. 1890. [As *Lactarius*]

Pileus fleshy, firm, convex to nearly plane, umbilicate, whitish, azonate, viscid, glabrous, 5–10 cm. broad, margin involute and

slightly tomentose at first, soon naked ; gills whitish, close, adnate to decurrent, narrow ; stem whitish, not spotted, obscurely rugulose-reticulated, 2.5–4 cm. long, 12–16 mm. thick ; spores subglobose ; latex white, unchanging, tardily acrid.

HAB.: Pine groves. August.

DISTRIB.: New York, *Peck.*

I have not seen this plant living, and the above description is arranged from the original description and from the dried specimens. The type specimens are in the herbarium of the N. Y. State Museum at Albany. The plant has not been found since the type collection and the dried specimens so closely resemble *L. affinis* Peck as to be indistinguishable from that species and at present I am inclined to regard it as the same.

* LACTARIA BLENNIA (Fr.) Epicr. 337. 1838. [As *Lactarius.*] —Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1[1]**: 217. 1898

Agaricus aerugineus Lamarck, Fl. Fr. 1 : (107.) 1778.

This species has been reported from Connecticut by White on the basis of specimens collected by Hanmer, and from Minnesota by Johnson. I have seen the Hanmer specimens and they are all *Lactaria turpis* (Weinm.) Fr. The Johnson specimens are not available for examination. For these reasons I omit this species from the list of our known *Lactariae.* A description of the species is given in McIlvaine's One Thousand Am. Fungi. The following may further help in the recognition of the species should it be found and will also enable one to avoid confusing it with related species.

DISTINGUISHING FIELD-MARKS : The grayish-green viscid pileus, zoned with drop-like concentric spots. It may be distinguished from *Lactaria turpis* (Weinm.) Fr. by the paler-green color, by the more inconspicuous down on the margin of the pileus and the otherwise glabrous surface and by the wounds of the gills turning cinereous. The gills do not become blackish in drying as do those of *L. turpis.* Regarded as poisonous.

VI. ASPIDEAE

Pileus very viscid when young or in wet weather, and the margin minutely tomentose or pruinose-downy to nearly glabrous

* The name of this species should be **Lactaria aeruginea** (Lamarck).

when young, wounds becoming lilac; gills somewhat darker with age and slightly pruinose.

While *Lactaria aspidea* and *Lactaria aspideoides* have a deciduous minute tomentum on the margin of the young pileus, the other species are merely pruinose-downy to almost glabrous, and all the species agree in being entirely glabrous when mature. This, together with the extreme viscidity of the pileus and the lilac color assumed by the wounds, indicates their relationship. *Lactaria speciosa* seems to be more closely related to the *Torminosae* by its very long tomentose covering and less viscid surface.

Synopsis of species

Pileus gray.	
Conspicuously zoned and spotted, 7–12 cm. broad.	**23.** *L. maculata.*
Faintly zoned or azonate, up to 8 cm. broad.	**22.** *L. lividorubescens.*
Pileus yellow.	
Azonate, latex acrid.	**20.** *L. aspidea.*
Zonate, latex bitter.	**21.** *L. aspideoides.*

20. LACTARIA ASPIDEA (Fr.) Fr. Epicr. 336. 1838. [As *Lactarius.*]— Hennings, in Eng. & Prantl, Nat. Pflanzenfam I[1**]: 218. 1898

Agaricus aspideus Fr. Obs. Myc. **2**: 189. 1818.
Agaricus roseo-violascens Lasch, Linnaea **3**: 161. 1828.

Pileus fleshy, not thick, plane to convex, slightly papillate, at length depressed, straw-colored, somewhat sordid, azonate, viscid, 3–10 cm. broad, margin at first with a zone of white silky deciduous tomentum, then entirely glabrous; gills white or cream, rather close, somewhat thick, of various lengths, here and there connected by branches,about 2 mm. broad; stem of the same color as the pileus or paler, nearly equal, even, glabrous, stuffed, then hollow, 5–8 cm. long, up to 15 mm. thick; flesh white, becoming lilac where wounded; spores globular, echinulate, 8–10 μ; latex white, changing to lilac, acrid. *Poisonous.*

HAB.: In moist places under willows, and in the border of woods. September.

DISTRIB.: New York, *Peck.*

ILLUST.: Lanzi, Fung. Mang. *pl. 56. f. 2. a, b, c, d;* Cooke, Br. Fungi, *pl. 1083; Agaricus pudibundus** Pico, Mém. Soc. Med. Par. *pl. 12.* 1780.

* This name was preoccupied. See Scop. Fl. Carn. **2**: 452. 1772.

DISTINGUISHING FIELD-MARKS: The pale-yellow or straw-colored pileus, the absence of zones, and the acrid latex.

This species has been found but once in the United States. Peck notes that the stem was not spotted in his specimens, and that the spores were broadly elliptical or subglobose.

Lactarius uvidus Krombh., which has commonly been referred to *Lactaria aspidea* Fr., does not seem to me to agree closely enough to warrant considering it this species. Krombholz describes the color of the pileus as "braun," and that of the stem and gills as white.

21. LACTARIA ASPIDEOIDES Burl. Bull. Torrey Club **34**: 87. 1907. [As *Lactarius*]

Pileus fleshy, rather firm, convex-umbilicate, then plane, becoming infundibuliform with age, sulphur-yellow (*18*) with narrow zones of butter-cup yellow (*22*), glabrous, 3–4.5 cm. broad, very viscid when wet, gluten thick and persisting, margin involute and minutely tomentose at first, then spreading and glabrous; gills whitish, then cream-colored spotted with yellow, staining lilac where wounded, sometimes forking next the stem, close, adnate, but acute at the inner end, 4 mm. broad; stem sulphur-yellow, often spotted with butter-cup yellow, equal or abruptly smaller at the base, viscid when young or wet, glabrous, stuffed, becoming hollow, 2–3.5 cm. long, 6–10 mm. thick; flesh whitish, changing to faintly lilac where exposed to the air; spores white, globular to broadly elliptical, echinulate, 5–7 μ × 7–8 μ; latex white, becoming lilac where in contact with the broken flesh, taste bitter.

HAB.: In grassy hillside sheep-pasture near small fir trees, after heavy rain and warm weather. September.

DISTRIB.: Vermont, 523 meters, *Burlingham 115*, 1906.

DISTINGUISHING FIELD-MARKS: The bright-yellow color of the entire plant, the very viscid zonate and glabrous pileus, the broad, short, chaff-like tomentum on the extreme edge of the young pileus, and the lilac color assumed by the wounded flesh or gills. The latex does not seem to change color except where in contact with the flesh. This species is most closely related to *L. aspideus* Fr., but differs in its brighter color, the zonate pileus, the smaller size, and the bitter latex. It can readily be distinguished from *L. speciosa*, since the pileus of the latter is covered with long tomentum and is pallid, with honey-colored zones. *L. aspideoides* is also a much smaller plant.

22. **Lactaria lividorubescens** (Batsch)

Agaricus lividorubescens Batsch, Elench. Fung. **2**: 51. *pl. 36. f. 202.* 1789.
Agaricus uvidus Fr. Obs. Myc. **2**: 191. 1818.
Lactarius uvidus Fr. Epicr. 338. 1838.
Lactarius livescens Passerini, Nuovo Giorn. Bot. Ital. **4**: 105. 1872.

Pileus fleshy, firm, then more lax, rather thin, convex, then plane to depressed, often umbonate, cinereous or brownish-gray, tinged with lilac, often faintly spotted and zonate especially when young, viscid, glabrous, 4–8 cm. broad, margin at first inrolled then spreading except the extreme edge, which remains inrolled for some time and is at first white-pruinose to minutely downy; gills white to cream, quickly changing to lilac then violet when wounded, sometimes a few forking next the stem, close, thin, of various lengths, adnate to slightly decurrent, up to 5 mm. broad; stem white to cream, not spotted or only obscurely so, equal or tapering upwards, a little viscid when moist, glabrous, sometimes tomentose at the base, stuffed, becoming hollow, 4–8 cm. long, 6–12 mm. thick; flesh white, changing to lilac where wounded; spores white, elliptical, echinulate, 7 μ × 8–12 μ; latex white at first, changing to dark-lilac or violet where in contact with the the flesh, acrid, sometimes bitter.

HAB.: On the ground in woods, in moist places. August and September.

DISTRIB.: New York, *Peck;* Maine, *White;* Vermont, *Burlingham 63,* 1906; Connecticut, *Earle, Benedict;* Maryland, *Banning.*

ILLUST.: Banning, Folio Md. Fungi, *pl. 80;* Batsch, Elench. Fung. *pl. 36. f. 202;* Bern. Champ. Roch. *pl. 37. f. 1;* Britz. Lact. *f. 16;* Cooke, Br. Fungi, *pl. 991;* Gillet, Champ. Fr. *pl. 48 (157; 399);* Pat. Tab. Analyt. Fung. *pl. 209.*

DISTINGUISHING FIELD-MARKS: The gray or brownish-gray, very viscid pileus, the paler stem, and the lilac color which all parts of the plant assume where touched. The pileus may be faintly zonate but is never conspicuously zoned or spotted as in *Lactaria maculata* Peck, and the plant is rarely as large as the smallest specimens of *Lactaria maculata.*

Most European mycologists describe the latex as changing color upon exposure to the air. In Monogr. **2**: 162, Fries says,

"*Lac raro album persistit.*" It was evidently on the strength of the unchangeable milk that Passerini described his specimens as a distinct species, *L. livescens.* In the Vermont specimens I repeatedly watched the latex for fifteen minutes or even longer, and I could never detect any change except where the drop was in contact with the broken flesh.

Krombholz' description, accompanying his *pl. 57. f. 7–9*,accords with the characters of *Lactaria lividorubescens* but the plate does not represent this species, nor does it agree with his description. And *pl. 57. f. 14, 16* can scarcely be positively referred to *Lactaria lividorubescens*, hence I have omitted both of these in the plates cited.

23. LACTARIA MACULATA Peck, Ann. Rep. N. Y. St. Mus. **41**: 74. 1888. [As *Lactarius*]

Pileus fleshy, compact, convex-umbilicate, then depressed in the center or at length infundibuliform, gray to lilac-gray, distinctly zoned with concentrically arranged darker spots, viscid, glabrous, 7.5–12.5 cm. broad, margin involute, naked, then spreading; gills whitish or cream-colored, sometimes forking, close, adnate to decurrent; stem of the same color as the pileus or paler, spotted, equal or tapering downwards, glabrous, hollow, 2.5–5 cm. long, 10–16 mm. thick; flesh grayish becoming lilac where wounded; spores subglobose, echinulate, 10–12.5 μ in diam.; latex creamy-white, becoming lilac, acrid and unpleasant.

HAB.: "In thin woods, and pastures" (Peck).

DISTRIB.: New York, *Peck;* Vermont, *Morgan.*

DISTINGUISHING FIELD-MARKS: This species is to be distinguished from *Lactaria lividorubescens* Batsch by its larger size, the firmer flesh, and the conspicuously spotted-zoned pileus and the absence of an umbo. The stem is also more spotted.

Lactaria maculata was first described as a variety of *Lactaria uvida* Fr., under the name *magnus*, but after further field-work, was separated as a distinct species. I have not found this species, but from an examination of the type specimens at Albany, I consider it to be distinct from *L. lividorubescens.*

VII. INSULSAE

Pileus very viscid, entirely glabrous, some shade of yellow, flesh firm, plants rather large; gills becoming neither perceptibly darker with age, nor pruinose; latex very acrid, white, unchanging

Synopsis of species

Pileus azonate, spores white.	25. *L. affinis.*
Pileus zonate.	
Spores yellowish.	24. *L. insulsa.*
Spores white.	*L. zonaria.**

24. LACTARIA INSULSA (Fr.) Fr. Epicr. 336. 1838. [As *Lactarius.*]— Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1[1**]: 216. 1898

Agaricus insulsus Fr. Syst. Myc. 1: 68. 1821.

Pileus fleshy, firm, at length somewhat lax, convex-umbilicate, becoming depressed in the center, coppery-orange (*56*) with alternating zones of deeper and lighter tones, sometimes yellowish-buff (*310*) zoned with coppery-orange, center coppery-orange to red-ochre (*32. t. 4*), viscid, glabrous, surface not polished, and often marked with striae like the stem of a *Russula*, 4.5–10 cm. broad, margin involute at first and remaining arched until the last; gills white, becoming dull-reddish along the margins where rubbed, frequently forking near the stem, adnate, becoming decurrent as the pileus deepens, thin, fragile, 2 mm. broad; stem paler than the pileus, sometimes spotted with deeper color, tapering downwards, glabrous, stuffed, then hollow, 1.5–5 cm. long, up to 10–12 mm. or more thick; flesh white, no odor; spores pale Naples-yellow (*29. t. 1, 2*), globose, strongly echinulate, 7–8 μ, rarely 6 μ; latex white, unchanging, very acrid. *Suspicious.*

HAB.: On the ground, in rather open woods or by trails in mixed deciduous woods. July and August.

DISTRIB.: New York, *Peck;* Maine, *White;* Vermont, *Burt;* North Carolina, 1,000 meters elevation, *Burlingham 37*, 1907; Alabama, *Underwood, Earle;* Missouri, *Glatfelter 303.*

ILLUST.: Berk. Outl. *pl. 13. f. 2;* Bres. Fung. Mang. *pl. 62;* Cooke, Br. Fungi, *pl. 975* (good); Gillet, Champ. Fr. *pl. 386;* *Agaricus flexuosus* Hussey, Illust. Br. Myc. *pl. 59* (good); Krombh. Abbild. *pl. 12. f. 1–6* (good); Lanzi, Fung. Mang. *pl. 56. f. 1, a, b, c* (good); Rich. & Rose, Atl. Champ. Fr. *pl. 37. f. 10–12.*

DISTINGUISHING FIELD-MARKS: The reddish or coppery-orange color of the glabrous viscid pileus, which is marked more or less prominently with zones, especially toward the naked, involute margin, the paler, usually spotted stem, the whitish gills, and the unchanging acrid latex. The color of the pileus is sometimes more

* European species, the occurrence of which in the United States is doubtful.

yellowish, and according to Peck, may be nearly straw-colored, but the prevailing color of the North Carolina and Alabama specimens was like that described in the European plant.

25. LACTARIA AFFINIS Peck, Rep. N. Y. St. Cab. **23**: 116. 1873.* [As *Lactarius*]

Lactarius platyphyllus Peck, Ann. Rep. N. Y. St. Cab. **23**: 118. 1873.

Pileus fleshy, firm, convex-umbilicate, then plane to depressed in the center, ochraceous-yellow, azonate, very viscid in wet weather, glabrous, 6–12 cm. or more broad, margin involute, then merely arched, even, naked; gills whitish or cream-colored, not changing with age, but often becoming pruinose in drying, many forking near the stem, not very close, adnate to slightly decurrent, 4–10 mm. broad; stem yellowish, paler than the pileus, often spotted, nearly equal, viscid when wet, stuffed, becoming hollow, 3–6 cm. long, 10–22 mm. thick; flesh white, unchanging; spores whitish, globose to broadly elliptical, echinulate, 8 × 10 μ; latex white, unchanging, acrid.

HAB.: On the ground in mixed balsam and maple woods. August and September. (Pastures and copses, October, Peck.)

DISTRIB.: New York, *Peck;* Vermont, *Burlingham 60*, 1906; Massachusetts, *Morris;* Maine, *White.*

DISTINGUISHING FIELD-MARKS: The dull ochraceous, zoneless pileus, and the broad rather distant gills. Frequently the center is darker, apparently owing to the gluten remaining there after the rest of the pileus is dry. The latex sometimes dries a pale dull-green on the gills. The species is very closely related to *Lactaria insulsa* Fr., but its constantly duller color and the absence of zones, together with the broader and more distant gills, seem to separate it as a distinct species.

Lactarius platyphyllus Professor Peck has decided is a large form of *Lactaria affinis*, and I have accordingly given it as a synonym.

DOUBTFUL SPECIES

LACTARIA ZONARIA (Lamarck) Fr. Epicr. 336. 1838. [As *Lactarius.*] — Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 538. 1889

Agaricus zonarius Lamarck, Fl. Fr. **1**: (108). 1778.

This species has been reported from Vermont by Frost, Rhode

* Separate published in advance in [Ap] 1872.

Island by Bennett, New Jersey by Ellis, Ohio by Morgan, Wisconsin by Bundy, Minnesota by Johnson, and from California by Harkness & Moore. I have seen only the Ellis specimens, in Ellis & Everhart, N. Am. Fungi, second series *1916*, and they do not resemble *L. zonaria*. The species is closely related to *L. insulsa* Fr., from which it differs in the firmer flesh, the unspotted stem, and the white spores. It is regarded by some as poisonous.

VIII. TRIVIALES

The triviales are characterized by the slimy-viscid glabrous pileus having the margin naked, and by acrid white latex. The latex does not change color, but in some species it stains the flesh or gills a pale dull gray-green. *L. trivialis* seems to be the most widely distributed species.

Synopsis of species

Pileus red. — 28. *Lactaria hysgina.*

Pileus not red.

Azonate; wounds of the gills becoming greenish.

Pileus gray to putty-colored, spores yellow. — 26. *Lactaria trivialis.*

Pileus sepia, spores white. — 29. *Lactaria mucida.*

Zonate; wounds of gills not changing color.

Pileus gray, zoned with raw-umber, fading to gray. — 27. *Lactaria circellata.*

26. LACTARIA TRIVIALIS (Fr.) Fr. Epicr. 337. 1838. [As *Lactarius.*]—Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 538. 1889

Agaricus trivialis Fr. Obs. Myc. **1**: 61. 1815.

Lactarius deflexus Lindblad, Monogr. Lact. Suec. 8. 1855.

Pileus fleshy, firm, depressed in the center with the margin arched, then plane to infundibuliform, plum-colored or smoke-gray, tinted with livid when young, fading, becoming putty-colored (*311. t. 1*) to snuff-brown (*303. t. 1*), or center darker with lilac tints (*196*), azonate, viscid, glabrous, up to 15 cm. broad, margin even, thin edge involute for some time, pruinose at first; gills cream-colored to yellowish, some forking, close, slightly decurrent, 5–7 mm. broad; stem cream-yellow, nearly equal but often inflated, glabrous, smooth, becoming hollow, 4–12 cm. long, 1–2 cm. thick; spores yellowish, elliptical, echinulate, 8 × 11 μ; flesh white, pale-greenish where the latex dries; latex white or creamy-white, unchanging, acrid.

HAB.: In mixed or deciduous woods. July to September.

DISTRIB.: New York, *Peck*, *Burlingham 3*, 1905; Vermont, *Burlingham*, *Frost;* New Hampshire, *P. Wilson;* Connecticut,

Earle, Hanmer 1826; Pennsylvania, *Herbst ;* * Virginia, 750 meters, *Murrill 173 ;* Tennessee, 400 meters, *Murrill 592 ;* North Carolina 1066 meters, *Burlingham 13,* 1907 ; Missouri, *Glatfelter 1249.*

ILLUST.: Britz. Lact. *f. 9 ;* Cooke, Br. Fungi, *pl. 976 ;* Krombh. Abbild. *pl. 14. f. 17, 18 ;* Lucand, Champ. Fr. *pl. 166.*

DISTINGUISHING FIELD-MARKS: The broad thick grayish pileus, which is depressed in the center, viscid, glabrous, and without zones ; the paler stout stem ; the creamy-white to yellowish gills, which become pale-greenish where the latex dries, or sometimes sordid where bruised ; and the very acrid milk. L. *trivialis* Fr. differs from *L. mucida* Burl. in being very much larger, grayish instead of sepia, and in having yellowish spores.

One form of this species may be recognized. It has been described by Peck as *L. trivialis gracilis* and differs in its small size and slender character (pileus 2.5–5 cm. broad, stem equal to or larger than the diameter of the pileus). Peck has described one other variety, *maculata* but I should hesitate to consider this a form of *L. trivialis*, or even a variety in the old sense, because I can find no mention of a zonate characteristic in the European plant, and I have never found *L. trivialis* with any indication of zones. I am inclined to regard this as either a specimen of *L. circellata* or as an undescribed species.

27. LACTARIA CIRCELLATA (Fr.) Fr. Epicr. 338. 1838. [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1^{1**}: 216. 1898

Agaricus circellatus Fr. Hym. Eur. 426. 1821.

Pileus fleshy, firm, convex, umbilicate, then plane becoming infundibuliform, gray to neutral tint, zoned and streaked with raw-umber (*301*), darker in the center, fading to gray when old, viscid in wet weather, glistening when dry, glabrous, 3–7 cm. broad, margin even, inrolled and pruinose at first ; gills white to cream-colored, margins ochraceous when bruised, forking near the stem, close, adnate with a decurrent tooth, appearing more decurrent with age, up to 5 mm. broad ; stem paler than the pileus, equal or tapering downwards, glabrous, smooth, firm, stuffed, at length hollow, up to 4 cm. long, 10–17 mm. thick ; flesh white, grayish next the cuticle ; spores white, subglobose, slightly echinulate, 6.5 μ × 7–8 μ, somewhat hyaline ; latex white, unchanging, acrid.

* In the Herbst collection this is labeled *L. turpis* (Weinm.) Fr.

HAB.: In moist mixed woods. August and September.

DISTRIB.: Vermont, 500 meters elevation, *Burlingham 59*, 1906.

ILLUST.: *Omphalomyces circellatus acris* Batt. Fung. Arim. *pl. 13. f. D;* Cooke, Br. Fungi, *pl. 990;* Gillet, Champ. Fr. *pl. 380;* Sowerby, Eng. Fungi, *pl. 203.*

DISTINGUISHING FIELD-MARKS: This species may be distinguished from *Lactaria pyrogala* and *Lactaria flexuosa* by its viscid pileus, and from *Lactaria trivialis* by its zonate pileus and white spores. Although zoned and streaked with umber at first, the pileus fades to an even rather pale gray when old. In this state it can be distinguished from *L. trivialis* by the absence of yellowish color in the center of the pileus, the unchanging gills, and the white spores.

28. LACTARIA HYSGINA (Fr.) Fr. Epicr. 337. 1838. [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1[1**]: 216. 1898

Agaricus hysginus Fr. Syst. Myc. 1: 67. 1821.

Pileus firm, fleshy, convex, then umbilicate, becoming depressed in the center, reddish-incarnate or blood-red-brown (*337*), darker in the center, shading into paler and even incarnate (*139. t. 1*) at the margin, fading with age, azonate, smooth, very viscid, viscidity persisting for some time, glabrous, smooth, 5–8 cm. broad, margin involute then arched and the extreme edge inflexed; gills white or creamy-white, becoming yellowish, often forking near the stem, close, adnate to slightly decurrent, 3–5 mm. broad; stem paler than the pileus, or sometimes of the same color, spotted with red or reddish-brown, nearly equal, viscid when wet, glabrous, stuffed, becoming hollow; flesh white in the pileus, reddish next the cuticle, faintly yellowish in the stem; spores whitish, subglobular to elliptical, echinulate, 6–8 μ × 8–10 μ; latex white, unchanging, acrid.

HAB.: In moist woods, especially near spruce trees, often in grassy places. July to September.

DISTRIB.: New York, *Peck;* Maine, *White;* Vermont, *Burlingham 57*, 1906.

ILLUST.; Britz. Lact. *f. 15* (poor); Cooke, Br. Fungi, *pl. 989;* Fries, Icon. *pl. 169. f. 2; Agaricus vietus* Krombh. Abbild. *pl. 14. f. 15, 16.*

DISTINGUISHING FIELD-MARKS: The red-brown azonate, very viscid pileus, acrid latex, and the medium-large size of the plant.

29. **Lactaria mucida** sp. nov.

Pileus fleshy, rather thin, convex-umbilicate, then plane, at length infundibuliform, warm-sepia (*305. t. 2, 3*) in the center, putty-colored (*311*) to stone-colored (*312*) on the extreme margin, azonate, very viscid and shining when wet, glabrous, 3–9 cm. broad margin, even at first, slightly wavy and striate in the old

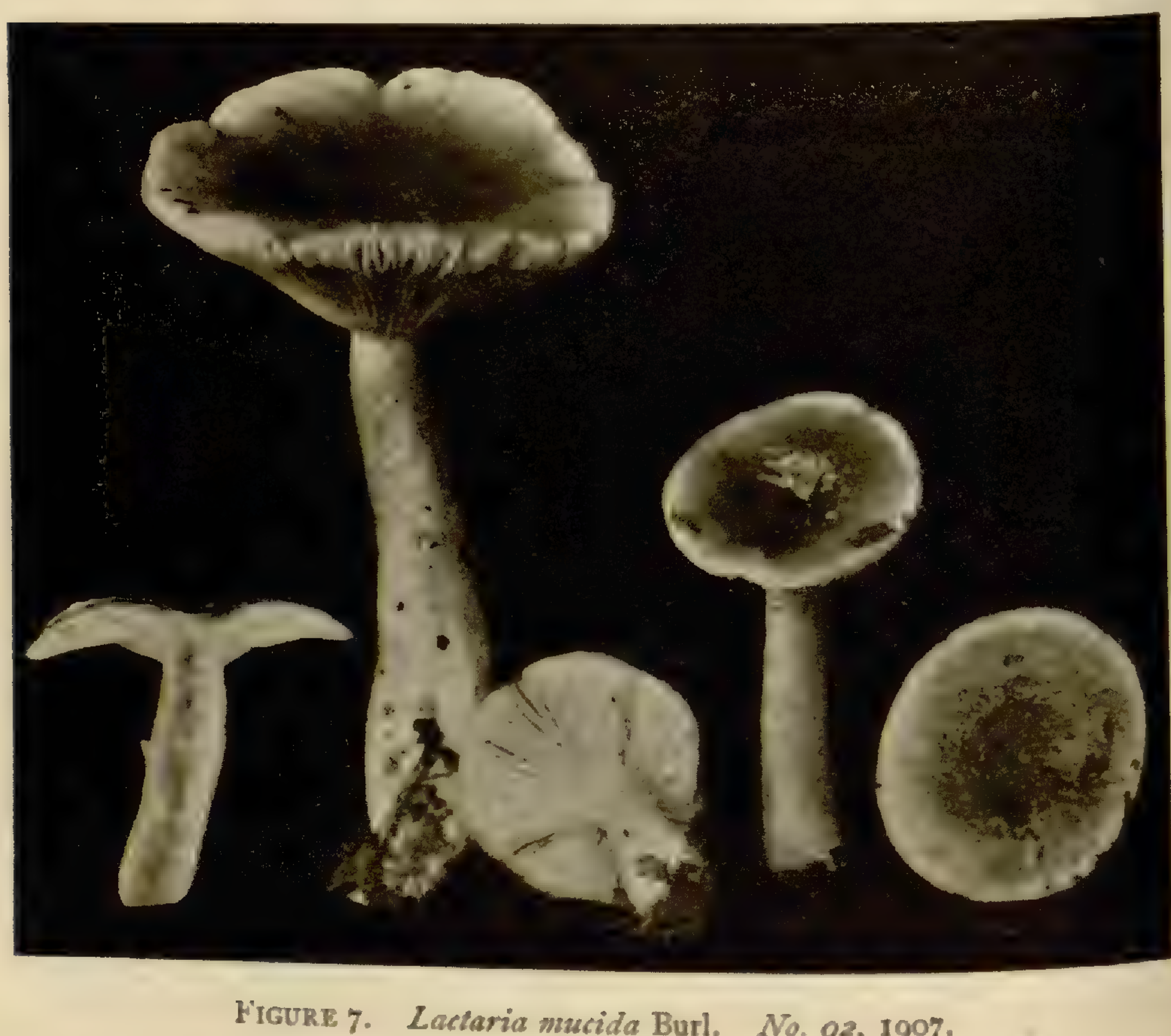

FIGURE 7. *Lactaria mucida* Burl. *No. 92*, 1907.

plant; gills white, scarcely changing color with age, staining blue-greenish-gray where the milk dries (*249. t. 1*), sometimes forking near the stem, close, adnate to slightly decurrent, acute at the inner end, up to 7 mm. broad; stem of the same color as the pileus or paler, tapering upwards, slightly viscid when wet, glabrous, sometimes with faint striae, stuffed, then hollow, 4–7 cm. long, 7–10 mm. thick at the top, 10–15 mm. at the base; flesh white, odor none; spores white, broadly elliptical, echinulate, 7–8 μ × 8–9.5 μ; latex white, drying blue-greenish-gray on the gills and the broken flesh, acrid. (FIGURE 7.)

HAB.: Under hemlocks, in wet weather. Late August and September.

DISTRIB.: Vermont, *Burlingham 91*, 1906; North Carolina, 1000 meters elevation, *Burlingham 92*, 1907 (type).

DISTINGUISHING FIELD-MARKS: This species may be easily recognized by the contrasting dark-sepia color of the center, the whitish color of the margin of the pileus, and its slimy shining appearance, as well as by the blue-greenish-gray color of the dried latex. It closely resembles *Lactaria cinerea* Peck in size and texture, but differs in the habitat, in the color of the pileus, and in the change in color of the more acrid latex. While *L. cinerea* is most abundant in August, *L. mucida* does not appear until late in August and is most plentiful in September. I have found it only under hemlock trees, while *L. cinerea* seems to grow only under beech trees. From *L. trivialis* it may be distinguished by the white spores, the smaller size, the more lax flesh, and the absence of lilac tints in the color of the pileus, which does not become yellowish in fading.

IX. DELICIOSAE

Latex deep-colored and rather mild, pileus viscid; wounds, or even the entire plant when old, often becoming greenish; spores yellowish.

Three species have been described from Europe, *Lactaria deliciosa*, *Lactaria sanguiflua*, and *Lactaria haemorrhea* Lowe, the first alone being common to Europe and America. The remaining three species have been reported only from North America. All of the species resemble *Lactaria deliciosa* L. in many respects and form with it a natural group of which it may be taken as the type. *Lactaria Chelidonium* is most closely related to *Lactaria deliciosa*, while *Lactaria subpurpurea* appoaches *Lactaria sanguiflua*. *Lactaria Indigo* diverges more from the type. *L. salmonea* Peck seems to belong rather with the *Fuliginosae*.

Synopsis of species

Latex orange-colored.	30. *Lactaria deliciosa.*
Latex saffron-yellow.	31. *Lactaria Chelidonium.*
Latex dark-red.	32. *Lactaria subpurpurea.*
Latex indigo-colored.	33. *Lactaria Indigo.*

30. LACTARIA DELICIOSA (L.) Fr. Epicr. 341. 1838. [As *Lactarius.*] —Schröt. in Cohn, Krypt.-Fl. Schles. 3: 543. 1889

Agaricus deliciosus L. Sp. Pl. 1172. 1753.

Pileus fleshy, firm, convex-umbilicate, becoming plane, at length infundibuliform, orange, yellow-orange or paler, zoned with deeper orange, becoming paler with age, sometimes mixed with grayish and greenish tints, viscid when wet, glabrous, surface somewhat roughened, 5–12 cm. broad, margin even, glabrous, involute, then arched, at length upturned; gills deep-orange with yellowish reflections, paler when old, and becoming greenish with age or where bruised, many forking near the stem and shorter gills forking into the longer, often connected with cross veins at the base, close, somewhat decurrent, rather narrow; stem of the same color as the pileus, spotted with brighter orange, nearly equal, glabrous, or sometimes a little hairy at the base, smooth, stuffed, becoming hollow, 2.5–10 cm. long, 8–12 mm. thick; flesh yellowish, staining greenish next the gills and the exterior of the stem; spores yellow, subglobose to elliptical, slightly echinulate, more or less hyaline, 8–8.5 μ × 8–11 μ; latex orange to red-orange, aromatic and somewhat acrid. *Edible.*

HAB.: In moist woods, especially under firs and hemlocks. August and September, or up to December and January in Florida.

DISTRIB.: New York, *Peck, Fisher, Burlingham 10*, 1905; Maine, *White;* Vermont, *Burlingham 44*, 1906, *Jones;* Connecticut, *Earle, Underwood;* Alabama, *Earle;* Florida, *Fawcett;* Colorado, 2680 meters elevation, *Clements.* It has also been reported from North Carolina by Schweinitz and by Curtis; from Ohio by Morgan; and from California by Harkness & Moore.

ILLUST.: Atkinson, Stud. Am. Fungi, *pl. 35. f. 1;* Badham, Escul. Fung. Eng. *pl. 6. f. 2;* Barla, Champ. Nice, *pl. 19. f. 1–5;* Bern. Champ. Roch. *pl. 39. f. 1;* Boyer, Champ. *pl. 32;* Bresadola, Fung. Mang. *pl. 64;* Britz. Lact. *f. 17;* Cooke, Br. Fungi, *pl. 982* (very good); Cordier, Champ. Fr. *pl. 25. f. 1* (poor); Eng. & Prantl, Nat. Pflanzenfam. 1[1**]: *f. 110 D;* Fl. Dan. *pl. 1131;* Gauthier, Champ. *pl. 11. f. 1* (bad); Gibson, Edible Toadstools and Mushrooms, *pl. 18;* Gillet, Champ. Fr. *pl. 49* [*166; 382*] (very good); Hahn, Der Pilz-Sammler, *f. 20;* Harzer, Pilze, *pl. 10* (good); Hussey, Illust. Br. Fung. 1: *pl. 67;* Krombh. Abbild. *pl. 11* (good); Lanzi, Fung. Mang. *pl. 53. f. 2* (good); Lorinser,

Essb. und Gift. Schwäm. *pl. 8. f. 5;* Lucand, Champ. Fr. *pl. 167* (good); McIlvaine, *pl. 41. f. 3* (poor); Noulet & Dass. Champ. *pl. 18. f. A* (bad); Rich. & Roze, Atl. Champ. Fr. *pl. 38. f. 1–5;* Rolland, Bull. Soc. Myc. Fr. **7**: *pl. 2. f. 2;* Schaeff. Fung. Bav. Icon. *pl. 11;* Sicard, Hist. Nat. Champ. *pl. 44. f. 237* (bad); Sowerby, Eng. Fungi, *pl. 202* (good); Fries, Sverig. Svamp. *pl. 6* (very good); Venturi, Studi Micol. *f. 55, 56;* Vittad. Descr. Fung. Mang. *pl. 42;* Viviani, Fung. Ital. *pl. 13.*

EXSIC.: Herpell, Sammlung präpariter Hutpilze *107;* Karsten, Fungi Fennici, *509;* Sydow, Mycotheca Marchica *610.*

DISTINGUISHING FIELD-MARKS: *Lactaria deliciosa* varies in color from orange to pale-yellow and is sometimes conspicuously zonedand again nearly azonate, but the color is always brighter and the zones are usually more marked than in *Lactaria Chelidonium*, and, while the latex may at first be saffron-yellow, it soon becomes red-orange and is always abundant. The color and the zonation of the pileus are most decided in the young plant. The change in the color of wounds from orange to greenish is often rapid, the whole plant becoming greenish where bruised or as it becomes old. At other times I have not been able to detect any greenish tint to the gills or other parts of the plant either with age or injury. The green color was very prominent in the specimens sent from Florida by Fawcett and it persisted in the dried mushroom.

31. LACTARIA CHELIDONIUM Peck, Ann. Rep. N. Y. St. Mus. **24**: 74. 1872. [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**[1**]: 218. 1898

Pileus fleshy, firm, convex, then plane with the center more or less depressed, "grayish yellow or tawny," at length stained with bluish and greenish, usually with two or three narrow zones near the margin, slightly viscid when wet, glabrous, 5–8 cm. broad, margin involute at first and naked; gills saffron-yellow mixed with gray, sometimes forking, close, "anastomosing or wavy at the base," adnate, then slightly decurrent, narrow; stem of the same color as the pileus, nearly equal, glabrous, becoming hollow, 2.5–4 cm. long, 10–12 mm. thick; flesh whitish, staining saffron-yellow from the latex, then becoming bluish and at length greenish; spores yellowish, globular to broadly elliptical, echinulate, $7 \times 8\ \mu$ ($9\ \mu$ Peck); latex saffron-yellow, mild, scanty. *Edible.*

HAB.: "Sandy soil under or near pine trees" (Peck); also in dry spruce woods.

DISTRIB.: New York, *Peck*, *Earle*; Vermont, *Burlingham*; Connecticut, *Underwood*; Alabama, *Earle*; it has also been reported from Vermont by Frost and from North Carolina by Atkinson.

ILLUST.: Atkinson, Stud. Am. Fungi, *pl. 35. f. 2.* 1900.

DISTINGUISHING FIELD-MARKS: It is a paler yellow and duller in color than *Lactaria deliciosa*, the flesh is firm, the pileus scarcely viscid, the zones marginal, the stem short, the gills narrow, and the latex saffron-yellow rather than orange. It is usually found in dry woods in the vicinity of pine trees, while *Lactaria deliciosa* is most abundant in mossy wet woods, especially near hemlocks.

The type specimens are in the herbarium of the N. Y. State Museum at Albany.

32. LACTARIA SUBPURPUREA Peck, Ann. Rep. N. Y. St. Mus. **29**: 43. 1878. [As *Lactarius*.] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**^{1**}: 218. 1898

Pileus fleshy, convex umbilicate, then plane to infundibuliform, dark-red (Indian-lake, *105. t. 1*) zoned with hydrangea-pink (*132. t. 1*), zones becoming less marked with age, and the entire pileus except the margin approaching hydrangea-pink with a grayish luster, margin becoming Etruscan-red (*132*), the whole spotted more or less with emerald-green (*259*) when mature, somewhat viscid when wet, glabrous, 3–8.5 cm. broad, margin involute and pruinose at first, then plane to uplifted, gills colored like the pileus and fading and greenish with age, seldom forking, rather distant, slightly decurrent, 6–7 mm. broad; stem of the same color as the pileus, often spotted with dark-red, equal or tapering upwards, glabrous or pruinose, sometimes tomentose at the base, stuffed, becoming hollow, 3–7 cm. long, 8–15 mm. thick; flesh whitish to hydrangea-pink, instantly staining red next the gills and the surface of the stem, after some time becoming greenish, odor faint; spores yellowish, broadly elliptical, echinulate, often uniguttulate, 7–8 μ × 8–10 μ; latex Morocco-red (*95. t. 4*), rather mild. *Edible.* (FIGURE 8.)

HAB.: Usually moist woods in the vicinity of hemlocks. August, September, and October.

DISTRIB.: New York, *Peck*, *Burlingham 9*, 1905; Vermont, *Burlingham 109*, 1906; Massachusetts, *Morris*; Connecticut, *Underwood*; North Carolina, *Burlingham 51*, 1907.

ILLUST.: Ann. Rep. N. Y. St. Mus. **54**: *pl. 70. f. 1–6.*

DISTINGUISHING FIELD-MARKS: The peculiar mixture of dull dark-red, hydrangea-pink, and grayish in the coloring of the plant, and the dull dark-red latex. It has been found at elevations varying from 130 meters in New York to 1000 meters in North Carolina.

FIGURE 8. *Lactaria subpurpurea* Peck. *No. 51*, 1907, *Burlingham.*

Bresadola's figure of *Lactaria sanguiflua* Fr. in Fungi Tridentini **2**: *pl. 126.* 1892, closely resembles *Lactaria subpurpurea* Peck, but his description of the color and the taste of the milk as well as of the color of the pileus would not indicate that he had that species in hand. The figure, however, seems to accord with *L. subpurpurea* much more than with *Lactaria sanguiflua* Fr.

33. LACTARIA INDIGO (Schw.) Fr. Epicr. 341. 1838. [As *Lactarius.*]—Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **I**^{1**}: 218. 1898

Agaricus lactifluus Indigo Schweinitz, Syn. Fung. Carol. Super. 61. 1818.

Pileus fleshy, firm, convex-umbilicate, becoming plane to infundibuliform, indigo-blue when wet, fading when drier, often with a grayish luster, zonate, sometimes spotted, 5–12 mm. broad, margin naked; gills indigo-blue or paler, at length yellowish or sometimes tinged with green, some forking near the stem, close, somewhat decurrent, rather broad; stem of the same color as the pileus, often spotted, nearly equal, glabrous, smooth, firm, becoming hollow, up to 5 cm. long, 1–2 cm. thick; flesh sky-blue to darker, often becoming greenish; spores yellowish, globular to broadly elliptical, echinulate, 7 μ × 8–9.5 μ; latex dark-blue. *Edible.*

HAB.: In dry pine or oak woods. July to October (and November in Florida).

DISTRIB.: New York, *Peck;* Connecticut, *Underwood, Hanmer;* Vermont, *Jones;* Maryland, *Banning;* Virginia, *Murrill;* North Carolina, *Schweinitz;* South Carolina, *Ravenel;* Alabama, *Underwood;* Georgia, *Harper;* District of Columbia, *Murrill 1522;* Florida, *Fawcett.* It has also been reported from Pennsylvania by Herbst.

ILLUST.: Atkinson, Stud. Am. Fungi, *pl. 35. f. 3;* Banning, Folio Md. Fungi, *pl. 82* (excellent); McIlvaine *pl. 41. f. 2.*

DISTINGUISHING FIELD-MARKS: The more or less indigo color or tint which characterizes the entire plant.

X. QUIETAE

Pileus covered with a thin viscidity when moist, soon dry, surface entire, glabrous, and margin naked, flesh more lax and the plants usually smaller than in *Limacina;* gills becoming decidedly darker with age, and dusted with the spores; latex mild or only slightly acrid.

In these plants the viscidity disappears so quickly that it may not be noticed in dry weather unless the mushrooms are collected in the morning while covered with dew.

Synopsis of species

* Pileus 2–4 cm. broad.

Latex mild.

Pileus mahogany-red, shining-viscid when moist. 35. *Lactaria nitida.*

Pileus fulvous, fading, papilla persisting dark. 36. *Lactaria oculata.*

Pileus brownish-drab to yellowish-brown, fading. 38. *Lactaria paludinella.*

Latex acrid.

Pileus fulvous, margin crenate to sulcate. 37. *Lactaria minuscula.*

** Pileus 5–15 cm. broad.

Latex mild.

Pileus dark-red to reddish-cinnamon. 34. *Lactaria quieta.*
Pileus pale leather-colored. *Lactaria pallida.* *

34. LACTARIA QUIETA Fr. Epicr. 343. 1838. [As *Lactarius.*]—Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 537. 1889

Agaricus quietus Fr. Syst. Myc. **1**: 69. 1821.

Pileus fleshy, rather thick, depressed in the center, dark-red to reddish-cinnamon, fading, obscurely zonate, viscid at first, soon dry, glabrous, 5–8 cm. broad, margin arched, even; gills white, becoming pale brick-red, sometimes forking near the stem, close, adnate to decurrent, 3–4 mm. broad; stem colored like the pileus, at length rubiginous, equal, glabrous, smooth, stuffed, at length hollow, 5–8 cm. long, up to 15 mm. thick; flesh white, becoming tinged with fulvous where broken, odor slight but disagreeable; spores white, echinulate, 8–10 μ × 6–7 μ; latex white, unchanging, mild. *Edible.*

HAB.: In deciduous woods.

DISTRIB.: New York, *Peck.*

ILLUST.: Cooke, Br. Fungi, *pl. 983.*

DISTINGUISHING FIELD-MARKS: This species may be distinguished from the other dark-red or fulvous-colored species in this group by the thicker pileus and stouter stem, and the faint zonation. The viscidity soon disappears, and Romell says: "I have never found this plant viscid."

35. LACTARIA NITIDA Burl. Bull. Torrey Club **34**: 89. 1907. [As *Lactarius*]

Pileus fleshy, rather thin, convex, then depressed in the center, umbonate, mahogany-red (*335*) more golden-red toward the margin, umbo persistently dark, otherwise fading when dry, shining-viscid when wet, glabrous, smooth, 3 cm. broad, margin remaining arched for some time, even; gills yellowish, becoming pruinose, sometimes forking, close, slightly decurrent, broad; stem mahogany-red, equal or sometimes ventricose when growing in wet places, stuffed, becoming hollow, 4.5–5 cm. long, 5–8 mm. thick; flesh faintly buff, turning a little reddish where cut; spores white, echinulate, 5–6 μ × 6–8 μ; latex white, unchanging, mild.

HAB.: In grassy sheep pasture near hemlocks and in moist woods. September.

* European, occurrence in United States doubtful.

DISTRIB.: Vermont, 500 meters elevation, *Burlingham 114*, 1906.

DISTINGUISHING FIELD-MARKS: The mild milk and the mahogany-red color of the pileus and stem, together with the shining varnished appearance of the pileus when moist and viscid, make this little plant easily recognizable.

The type specimens are in the herbarium of the N. Y. Botanical Garden.

36. LACTARIA OCULATA (Peck) Burl. Bull. Torrey Club **34**: 89. 1907. [As *Lactarius*]

Lactarius subdulcis oculatus Peck, Bull. N. Y. St. Mus. **67**: 37. 1903.

Pileus fleshy, thin, convex, then depressed in the center, umbonate, rich-fulvous in the center, shading to buff-fulvous toward the margin, all except the papilla fading to pinkish with age, viscid in dew or wet weather, glabrous, smooth, 1.5–2.5 cm. broad, margin involute and pruinose at first, then arched and finally nearly plane, slightly crenate; gills whitish, then yellowish, at length pruinose, a few forking near the stem, close, slightly decurrent, rather broad, stem buff at the top, sublatericeous below the middle, equal, slightly viscid when wet, tomentose at the base, stuffed, up to 6 cm. long, 5 mm. thick, flesh buff-whitish; spores white, broadly elliptical to subglobose, echinulate, 6–7.5 μ × 8–9.5 μ; latex white, unchanging, mild.

HAB.: Under pine, hemlock, spruce, and balsam-fir trees, often in moss. July to September.

DISTRIB.: New York, *Peck;* Vermont, 500 meters elevation, *Burlingham 107*, 1906.

ILLUST.: Peck, Bull. N. Y. St. Mus. **67**: *pl. 83. f. 20–24.*

DISTINGUISHING FIELD-MARKS: The thin viscidity and fulvous color of the moist pileus, and the dark-fulvous or chestnut-colored spot which remains in the center of the pileus when the plant is dry. The viscidity and the expallent color separate this species from *L. subdulcis* (Pers.) Fr., while its larger size, paler color, mild milk, and persistent "eye-spot" serve to distinguish it from *L. minuscula* Burl.

37. LACTARIA MINUSCULA Burl. Bull. Torrey Club **34**: 88. 1907.
[As *Lactarius*]

Pileus fleshy, thin, broadly convex, with a small umbo, becoming plane then somewhat depressed in the center, fulvous in the center, cinnamon (*323. t. 1*) toward the still paler margin, azonate, viscid in wet weather, sometimes shining with viscidity, glabrous, 1–3 cm. broad, margin minutely crenate sometimes sulcate, often slightly wavy, pruinose at first; gills whitish, seldom forking, close, adnate or decurrent by a tooth, broad for the thickness of the pileus; stem fulvous near the base but paler toward the pileus,

FIGURE 9. *Lactaria minuscula* Burl. *No. 56*, 1907.

FIGURE 10. *Lactaria minuscula* Burl. *No. 56*, 1907.

equal, glabrous, sometimes tomentose at the base when growing in moss, stuffed, becoming hollow, 2.5–4.5 cm. long, 3–4 mm. thick; flesh isabelline-white; spores white, subglobose, slightly echinulate, 6–8 μ; latex white, unchanging, acrid. (FIGURES 9, 10).

HAB.: In moist woods, in moss or on decayed wood, under yellow birches, black gum, and black oak. July and August.

DISTRIB: New York, *Peck;* Vermont, 500 meters, *Burlingham;* North Carolina, 1,000 meters, *Burlingham 56*, 1907.

DISTINGUISHING FIELD-MARKS: This species differs from all others in this group in its small size, crenate margin, and more acrid latex. It may be distinguished from *L. subdulcis* by its viscid pileus, and by being expallent. It is frequently solitary.

38. LACTARIA PALUDINELLA Peck, Ann. Rep. N. Y. St. Mus. 38: 133. 1885. [As *Lactarius.*]—Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1[1**]: 214. 1898

Pileus fleshy, thin, convex, then plane-umbilicate to depressed in the center, sometimes with a small umbo, brownish-drab (*302. t. 2*) to dark-fawn (*307*),* expallent, slightly viscid when wet, glabrous, 12 mm. to 4 cm. broad, margin at length slightly striate; gills white to cream-colored, becoming darker with age, pruinose, many forking near the stem, close, adnate or slightly decurrent, thin, up to 4 mm. broad; stem of the same color as the pileus or paler, nearly equal, glabrous, except at the base, which is slightly villose when growing in moss, stuffed, sometimes hollow, 2–3 cm. long, 3–4 mm. thick; flesh white, or tinted with the color of the surface; spores white, subglobose, echinulate, 6.5–8.5 μ; latex white, unchanging, mild.

HAB.: In marshy places in woods, in *Sphagnum*, or in decaying leaves. August.

DISTRIB.: New York, *Peck;* Vermont, *Burlingham;* North Carolina, *Burlingham 82*, 1907.

DISTINGUISHING FIELD-MARKS: The sordid-brown color or the mixture of brownish-drab and yellow-brown, which gives the moist pileus a mottled, streaked, and subzonate appearance, and the striatulate margin. The species is small and is rendered inconspicuous by its dusky coloring. It occurs only in densely shaded places.

DOUBTFUL SPECIES

LACTARIA PALLIDA Pers. Tent. Disp. Meth. Fung. 64. 1797.

This species has been reported from Rhode Island by Bennett, Connecticut by White, and Minnesota by Johnson. I have seen Hanmer's *no. 1399*, which was cited as *pallida* by White, and it is not that species, but a pale form of *L. lactiflua* (L.). The plants from which the other determinations were made are not available for examination, and there is a reasonable doubt whether *L. pallida* occurs within the United States. It is edible.

XI. CINEREAE

Pileus more viscid than in the *Quietae*, of some shade of gray, perfectly glabrous, flesh lax and thin, plants rather fragile; gills becoming darker with age and pruinose; latex soon acrid.

* A yellowish-brown color, not fulvous.

Lactaria cinerea has been classed with the *Limacini* by Saccardo, but seems to belong rather to *Russularia* on account of the less acrid latex, the less viscid pileus, the more lax flesh, as well as the changing gills.

Synopsis of species

Latex white, not staining gills.	39. *Lactaria cinerea.*
Latex white, becoming gray.	*Lactaria vieta.* *

39. LACTARIA CINEREA Peck, Rep. N. Y. St. Bot. **24**: 73. 1872. [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**[1]**: 217. 1898

Pileus fleshy, thin, lax, convex at first, soon umbilicate to depressed in the center, at length infundibuliform, cinereous (*358*),

FIGURE 11. *Lactaria cinerea* Peck. *No. 105, 1907, Burlingham.*

darkest in the center, becoming pale toward the margin, fading, occasionally zonate, viscid when wet, glabrous, 2–5 cm. broad, margin involute at first, at length arched or uplifted, even; gills white, not changing color where bruised, often appearing pruinose, especially in dried plants, a few forking within 1 or 2 mm. of the stem, close, adnate, rather narrow; stem of the same color as the

* European species, the occurrence of which in the United States is uncertain.

pileus or paler, subequal but more often tapering upwards, frequently tomentose at the base, otherwise glabrous, spongy, soon hollow, 3–8 cm. long, 8–16 mm. thick; flesh white, not changing color; spores white, subglobose, minutely echinulate, 5.5–7 μ; latex white, unchanging, very acrid after a few seconds on the tongue. (FIGURE 11.)

HAB.: Under beeches or among beech leaves. July and August.

DISTRIB.: New York, *Peck, Earle;* Connecticut, *Underwood & Earle;* Maine, *White;* Vermont, *Morgan, Burlingham 13,* 1906; North Carolina, 1000 meters, *Burlingham 105,* 1907.

DISTINGUISHING FIELD-MARKS: The uniform pale-gray color, the thin pileus, which is glabrous, viscid, and usually azonate, but sometimes faintly zonate from the margin half-way to the center, the spongy stem, which usually tapers upwards, and the white close gills, which often become pruinose and do not become stained from the latex. I have found *Lactaria cinerea* only under or in the vicinity of beech trees. In North Carolina I rarely failed to find several specimens of it wherever even a solitary beech tree was growing in the midst of the oak-chestnut woods.

The type specimens of the species are in the State Herbarium at Albany. Many of the specimens which I found in Vermont and a few of North Carolina plants were faintly but decidedly zonate, the zones being narrow and more prominent toward the margin. Specimens collected by Morgan had this same characteristic. Peck considered the species to be related to *L. vieta* Fr. and it seems to belong in the group with this rather than with the *Limacini*, where it is placed by Saccardo. *Lactaria mucida* seems to stand between *L. cinerea* and *L. trivialis*, but is more closely related to the latter by the more acrid milk and the very slimy pileus.

DOUBTFUL SPECIES

LACTARIA VIETA (Fr.) Fr. Epicr. 344. 1838. [As *Lactarius.*] — Schröt. in Cohn, Krypt.-Fl. Schles. 3: 541. 1889

This species was reported from Ohio by Morgan in his Mycologic Flora of the Miami Valley, but as the specimens are not preserved it is impossible to verify the determination. His description would indicate that he had the species which he thought. For this reason I append the following description:

Pileus fleshy, lax, thin, convex, subumbonate, then expanding, umbilicate to infundibuliform, incarnate, or livid-gray, fading to grayish, azonate, viscid when wet, finely silky when dry, 4–6 cm. broad, margin even, involute at first, then arched to uplifted; gills white then yellowish, thin, close, somewhat decurrent, 2 mm. broad; stem of the same color as the pileus, equal or tapering upwards, glabrous, dry, stuffed, becoming hollow, 5–8 cm. long, 4–6 mm. thick; flesh whitish, odor faint, but somewhat pungent; spores 8 μ, nearly globose, minutely echinulate; latex white, becoming gray, mild, then acrid.

HAB.: Damp woods.

ILLUST.: Britz. Lact. *f. 21*; Cooke, Br. Fungi, *pl. 1009*; Fries, Icon. *pl. 170. f. 1*; Gillet, Champ. Fr. *pl. 167.* [*401*]; Lucand, Champ. Fr. *pl. 96.*

EXSIC.: Sydow, Mycotheca Marchica *2721.*

XII. THEIOGALAE

Pileus slightly viscid when moist, soon dry, glabrous, margin naked or minutely pruinose-downy in the young plant when viewed with a lens, whitish to isabelline or fulvous or pinkish-buff; flesh rather thick and firm at first, then thinner and lax; gills becoming darker with age, and more or less pruinose; latex bitter or acrid, white, becoming yellow.

Synopsis of species

Latex very acrid, becoming golden-yellow.	42. *L. chrysorhea.*
Latex mild, bitterish, then acrid, becoming sulphur-yellow.	
Pileus whitish, entire plant becoming brownish-red with age, azonate.	41. *L. colorascens.*
Pileus pinkish-buff to reddish terra-cotta or fulvous, zonate.	40. *L. theiogala.*
Pileus pallid, azonate.	40. *L. theiogala brevis.*

40. LACTARIA THEIOGALA (Bull.) Fr. Epicr. 342. 1838. [As *Lactarius.*] — Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 541. 1889

Agaricus theiogalus Bull. Herb. Fr. *pl. 567. f. 2.* 1793; Hist. 1: 495. 1809.

Hypophyllum lateritium Paulet; Paulet & Léveillé, Icon. Champ. 59. 1855.

Lactarius brevipes Longyear, Rep. Mich. Acad. Sci. **3**: 59. 1901.

Lactarius brevis Peck, Bull. N. Y. St. Mus. **94**: 33. 1905.

Lactarius xanthogalactus Peck, Bull. Torrey Club **34**: 346. 1907.

Pileus fleshy, firm and rather thick at first, then thinner and more lax, convex, sometimes with a small umbo, sometimes slightly umbilicate, then plane to depressed, incarnate-isabelline to yellowish-salmon (*65. t. 1–4*) or reddish-terra-cotta (*100*) to fulvous, more or less zonate, occasionally much paler and nearly or quite azonate, viscid when wet, glossy when dry, glabrous, 5–8 cm. broad, margin inrolled at first, and pruinose to very minutely pruinose-downy on the extreme edge ; lamellae whitish to yellowish, reddish-brown

FIGURE 12. *Lactaria theiogala* (Bull.) Fr. *No. 44*, 1907, *Burlingham.*

when old or when injured, some forking near the stem, close, adnate or a little decurrent, up to 4 mm. broad ; stem colored like the pileus or paler, sometimes faintly spotted, glabrous except at the base, which is often slightly tomentose, smooth, full and rather firm, at length hollow, 3–7 cm. long, 7–13 mm. thick ; flesh white, becoming yellow from the latex, odor pungent, disappearing in drying ; spores whitish, minutely echinulate, subglobose to broadly elliptical, 6–7 μ × 8–9 μ, latex white, changing to sulphur-yellow, bitterish then acrid. *Suspicious.* (FIGURE 12.)

HAB. : In both dry and moist woods, under spruce and fir trees, or in oak woods. August and September.

DISTRIB. : New York, *Peck, Earle, Burlingham ;* Maine, *White ;*

Vermont, *Jones*„*Frost*, *Burlingham 30*, 1906; Massachusetts, *Davis;* Connecticut, *Earle*, *Hanmer 2335;* Pennsylvania, *Herbst;* Maryland, *Shear;* Alabama, *Earle;* North Carolina, *Burlingham 44*, 1907; California, *Patterson.*

ILLUST.: Barla, Champ. Nice, *pl. 27. f. 14–16;* Bull. Herb. Fr. *pl. 567. f. 2;* Cordier, Champ. Fr. *pl. 27. f. 2;* Gillet, Champ. Fr. *pl. 164.* [*396*]; Krombh. Abbild. *pl. 1. f. 23, 24;* Lanzi, Fung. Mang. *pl. 32. f. 3, a, b, c;* Paulet & Lév. Icon. Champ. *pl. 71. f. 1–4;* Rich. & Roze, Atl. Champ. Fr. *pl. 37. f. 7–9;* Sicard, Hist. Nat. Champ. *pl. 43. f. 233.*

EXSIC.: Ellis & Everhart, N. Am. Fungi *1915;* Arcangeli, Erb. Critt. Ital. ser. 2, *807;* Herpell, Sammlung präpariter Hutpilze *132.*

DISTINGUISHING FIELD-MARKS: This species is somewhat difficult to determine from a description because of the rather wide variations it shows in different habitats. The latex more or less quickly turns to sulphur-yellow and the broken flesh has at first a pungent and characteristic odor which is an assistance in distinguishing the plant. The milk and the odor, together with the yellowish-salmon, sometimes more or less fulvous, color of the faintly zonate, slightly viscid pileus, will serve as determining characteristics for typical forms. The viscidity disappears very readily and the pileus is often absolutely dry and shining.

In shady dry woods, I have found the pileus to be rather pale, varying from whitish to pale-flesh color (*136. t. 4*) and from azonate to obscurely zonate as in my *nos. 30B*, 1906, and *2*, 1907, while in wet localities or in the open, I have found the color more yellowish-salmon or approaching fulvous, and the zones well marked. *No. 68*, 1907, which was growing in a little hollow made very wet by rain, was a striking example of this tendency. *Nos. 1012* and *1357*, herb. N. Y. Bot. Garden, collected by Earle, are intermediate forms between such pale forms as are represented by *L. brevis* Peck or *L. brevipes* Longyear, and the more distinctly zonate forms. *L. brevis* Peck seems to me to be an extreme form of *L. theiogala* (Bull.) Fr., and, although the original description gives the pileus as azonate, the type specimens show in some cases faint indications of zones. Further, the presence of tomentum on the stem base of *L. theiogala* is not constant, but may be found

in either the pale azonate or the darker zonate forms. While the size of the pale forms is usually much less than that of the darker, I have found typical forms of the species as small as the size given for *L. brevis* Peck. The stem of plants of *L. theiogala* growing in dry woods is usually firm and stuffed. Since the distinguishing characteristics given for *L. brevis* — white or whitish color, smaller size, solid or stuffed stem, and absence of tomentum from the base of the stem — are all present in *L. theiogala* under varying conditions of habitat, and intermediate forms exist between the typical *L. brevis* Peck and *L. theiogala* (Bull.) Fr., I am inclined to regard the former as a form of the latter due to ecological factors. *L. brevipes* Longyear I believe to be founded on immature specimens of a small pale form of *L. theiogala* and probably the same as *L. brevis* Peck.

The type specimens of *L. xanthogalacta* correspond to small plants of *L. theiogala*. This species was described from dried plants collected in California and the accompanying field-notes indicated that the milk was yellow, upon which character the species was based. But since the latex of *L. theiogala* often becomes yellow so quickly as to seem to be yellow from the first, and since the type specimens of *L. xanthogalacta* resemble exactly similar specimens of *L. theiogala*, I have no doubt as to their identity with the latter species.

41. LACTARIA COLORASCENS Peck, Bull. N. Y. St. Mus. **94**: 33. 1905. [As *Lactarius*]

Pileus fleshy, thin, nearly plane, becoming depressed in the center, whitish at first, becoming brownish-red with age, azonate, moist, glabrous, 2–5 cm. broad; gills whitish, becoming colored like the mature pileus, close, thin, adnate, or slightly decurrent; stem whitish, then brownish-red, equal, even, solid, 2.5–4 cm. long, 4–6 mm. thick; spores globose, echinulate, 8 μ; milk white, becoming sulphur-yellow, bitter.

HAB.: Woods. August.

DISTRIB: New York, *Peck*, *Atkinson* (Long Island).

DISTINGUISHING FIELD-MARKS: The change in color from pallid in young specimens to brownish-red in the mature plants, and the bitter white milk which becomes sulphur-yellow upon exposure to the air. Peck says that the color of the mature plants is similar to that of *L. camphorata*.

The type specimens which are in the herbarium of the N. Y. State Museum at Albany are those taken by Atkinson at Port Jefferson, L. I. The description does not indicate whether the pileus is viscid or dry in wet weather, but the relationship seems to be with *L. theiogala* (Bull.) Fr.

42. LACTARIA CHRYSORHEA Fr. Epicr. 342. 1838. [As *Lactarius.*]—Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 541. 1889

Pileus fleshy, firm, rather thick, convex-umbilicate, then infundibuliform, whitish to yellowish tinged with flesh color, usually zoned with golden-yellow or pale-orange, slightly viscid when moist, glabrous, 2.5–10 cm. broad, margin involute at first and covered with a minute down, then spreading and naked; gills white then yellowish, some forking, close, adnate to slightly decurrent, thin; stem white, then colored like the pileus, sometimes with bright-colored spots, pruinose, glabrous except at the base, which is more or less villose, stuffed, then hollow, 2.5–8 cm. long, 6–15 mm. thick; flesh white, becoming yellow where injured; spores white, subglobose, minutely echinulate, 7–8 μ; milk white, becoming golden-yellow, very acrid.

HAB.: Mixed woods or groves. August and September.

DISTRIB.: New York, *Peck;* North Carolina, *Atkinson, Burlingham 100,* 1907, 1000 meters.

ILLUST.: Atkinson, Stud. Am. Fungi, *f. 122;* Cooke, Br. Fungi, *pl. 984;* Gillet, Champ. Fr. *pl. 50 [151; 379];* Hahn, Der Pilz-Sammler, 5. *f. 20;* Krombh. Abbild. *pl. 12. f. 7–14;* Lucand, Champ. Fr. *pl. 5.*

DISTINGUISHING FIELD-MARKS: The white to yellowish color of the plant, the indistinct zones which are made up of brighter-colored spots concentrically arranged, and the acrid milk. The zones and spots become more prominent with age and in drying, and while the zones may be nearly lacking in the fresh plant, they may be conspicuous in the dried specimen. The species is apparently closely related to *L. theiogala* Fr., from which it is readily distinguished by the brighter, yellow tones, the spotted character of the zones, the absence of odor in the fresh plant, and the acrid milk.

This species is classed by Saccardo with the *Piperati,* but it seems to me to belong rather with *Russularia* on account of its slightly viscid pileus and the changing color of the gills. If the

pileus were more decidedly viscid, its acrid milk would indicate its relationship with the *Sublimacina*.

XIII. HELVAE

Pileus dry, varying from velvety to flocculose, floccose-squamulose, or squamulose, at least at first, color bay-red to fulvous, fulvous-isabelline, and testaceous, flesh rather thin, and lax, except in one species; gills becoming darker with age, and pruinose; latex white and unchanging, acrid, or watery and subacrid to mild.

Synopsis of species

Pileus azonate.
- Latex white, very acrid.
  - Pileus red, umbonate, minutely flocculose at first, soon glabrous. 44. *L. rufa.*
  - Pileus red, not umbonate. 47. *L. rufula.*
- Latex white, acrid; pileus fulvous to isabelline, squamulose. 46. *L. alpina.*
- Latex watery, mild or subacrid, rarely white; pileus testaceous, fading to isabelline, floccose-squamulose. 43. *L. helva.*

Pileus zonate.
- Latex white, acrid; pileus brick-red to reddish-terra-cotta, velvety. 45. *L. Peckii.*

43. LACTARIA HELVA (Fr.) Fr. Epicr. 347. 1838. [As *Lactarius.*]
— Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 539. 1889

Agaricus helvus Fr. Syst. Myc. **1**: 72. 1821.
Lactarius aquifluus Peck, Rep. N. Y. St. Mus. **28**: 50. 1877.
Lactarius aquifluus brevissimus Peck, Rep. N. Y. St. Mus. **51**: 298. 1897.

Pileus fleshy, fragile, convex, then plane to depressed, subumbonate, testaceous to isabelline, expallent, azonate, dry, the whole surface broken up into floccose-granulose squamules, sometimes rivulose, 5–15 cm. broad, margin involute at first, then spreading; gills white, then tinted with incarnate, finally yellow, often forking, close, decurrent, 2–3 mm. broad; stem pale-testaceous, equal, pruinose, pubescent at the base, stuffed, then hollow, 5–8 cm. long, 1 cm. or more thick; spores globose, echinulate, hyaline, 6–7 μ; flesh of the same color as the pileus but paler, odor faint, sweet, persistent in drying; latex white, scanty, subacrid, more often watery and mild or subacrid. *Edible.*

HAB.: In mossy rather wet woods or marshes. "In pines, frequently degenerate in swampy places" (Fries).

DISTRIB.: New York, *Peck* (*L. aquifluus*); Massachusetts, *Morris;* Connecticut, *Hammer 1469;* Pennsylvania, *Herbst;* re-

ported from North Carolina by Schweinitz, from Maine by Ricker, from Ontario, Canada, by Guillet.

ILLUST.: Bres. Fung. Trid. *pl. 39, 127;* Britz. Lact. *f. 30* (very poor); Cooke, Br. Fungi, *pl. 994.*

EXSIC.: Sydow, Mycotheca Marchica *2719.*

DISTINGUISHING FIELD-MARKS: The rather large size, the tawny buff-colored, dry, floccose-squamulose pileus, the usually watery milk, and the aromatic odor, which persists in drying.

Fries describes the latex as white except when the plant is growing in wet places. Romell says "The milk is watery; I have never found it white"; and Stevenson writes in British Fungi, "It occurs most frequently in marshes with watery juice." Thus far the American form has been found only with watery juice, and on this characteristic Peck has described it as a distinct species, *L. aquifluus.* He says "I have never found this plant with a white or milky juice, and therefore I am disposed to regard it not as a variety of *L. helvus*, but as a distinct species." The type specimens of *Lactarius aquifluus* agree in form and color with the *2719* Sydow, with Hennings' Berlin specimens, and with specimens sent from Stockholm by Romell. Since also the European plant occurs most frequently with watery juice, it would seem hardly possible to separate our plant as a distinct species, but *L. helva* may be considered as showing a variation in the character of the latex from white to watery, the latter being the usual form. It is probable that this difference in the latex is due to ecological conditions, but the mushroom most commonly grows in wet mossy places, and the prevailing form of the species scarcely seems to be degenerate, as Fries suspected; we probably have rather a hydrophilous plant, which in the dry condition might have more scanty white latex. The short-stemmed form I consider to be due to habitat.

44. LACTARIA RUFA (Scop.) Fr. Epicr. 347. 1838. [As *Lactarius.*] —Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 539. 1889

Agaricus rufus Scop. Fl. Carn. **2**: 451. 1772.

Pileus fleshy, not very compact, rather thin, convex, umbonate, at length infundibuliform, bay-red to rufous, not fading, azonate, dry, minutely flocculose-silky, then glabrous and shining, 5–10 cm. broad, margin involute at first, whitish-downy, then glabrous; gills ochraceous, then rufous, sometimes forking, close, somewhat

decurrent, 3 mm. broad ; stem rufous, but often paler than the pileus, nearly equal, dry, glabrous, or sometimes pruinose and downy at the base, stuffed, firm, at length sometimes hollow, 5–10 cm. long, 6–10 mm. thick ; flesh pallid or tinged with pink, no odor ; spores white, subglobose to broadly elliptical, slightly echinulate, 7–8 μ ; latex white, unchanging, very acrid. *Very poisonous.*

HAB.: "Low woods and swamps" (Peck). August.

DISTRIB.: New York, *Peck ;* Michigan, *Longyear.*

ILLUST.: Cooke, Br. Fungi, *pl. 985 ;* Eng. & Prantl, Nat. Pflanzenfam. **I**^{1**}: *f. 110 A ;* Fr. Sverig. Svamp. *pl. 11 ;* Gillet, *pl. 163* [*391*]; Gauthier, Champ. *pl. 12. f. 1, 2* (poor); Hahn, Der Pilz-Sammler, ed. 2. *f. 15* (poor); Hussey, Illust. Br. Myc. **I** : *pl. 15 ;* Krombh. Abbild. *pl. 39. f. 12–15 ;* Lanzi, Fung. Mang. *pl. 52. f. 2. a, b, c* (coloring poor); Lucand, Champ. Fr. *pl. 223 ; Hypophyllum torminosum* Paulet, Icon. Champ. *pl. 22 ;* Rolland, Bull. Soc. Myc.Fr. **7** : *pl. 2. f. 3 ;* Rich. & Roze, Atl. Champ. Fr. *pl. 37. f. 16–19.*

EXSIC.: Herpell, Sammlung präpariter Hutpilze *108 ;* Karsten, Fungi Fennici *226 ;* Krieger, Fungi Saxonici *480 ;* Sydow, Mycotheca Marchica *609* and *2720.*

DISTINGUISHING FIELD-MARKS: The dark-red, dry, umbonate pileus, the whitish down on the incurved margin of the young pileus, the very acrid milk, and the large size of the plant. The pileus is only minutely flocculose at first and soon becomes glabrous and shining. The species seems to be rare in the United States. It has been reported from Vermont by Frost and from Rhode Island by Bennett.

45. **Lactaria Peckii** sp. nov.

Pileus fleshy, firm, broadly convex, becoming depressed in the center, sometimes umbonate, latericeous (*330*) to reddish-terra-cotta, (*100. t. 2*) zoned with darker tones, fading with age, dry, covered with a short tomentum somewhat like the pile on plush, at length nearly glabrous in the center and sometimes areolate, 5–15 cm. broad, margin involute for some time, then merely arched, sometimes flexuous in old plants, at first striate with darker streaks ; gills pale-buff (*64*), soon becoming tinged with mineral-brown (*339*) and reflecting buff in one light and mineral-brown in another, finally becoming madder-brown, mostly entire, close, decurrent by a tooth, 3 mm. broad ; stem dull pale reddish-

FIGURE 13. *Lactaria Peckii* Burl. *No. 1, 1907.*

terra-cotta, usually paler than the pileus, sometimes spotted with reddish-brown, becoming darker where bruised, nearly equal or abruptly smaller at the base, glabrous or merely with a whitish bloom, firm, stuffed, becoming hollow in the mature plant, up to 4.5 cm. long, 1–2 cm. thick; flesh tinted with terra-cotta; spores whitish, subglobose, strongly echinulate, 7–8 μ; latex white, unchanging, astringent, then very acrid, abundant. (FIGURE 13.)

HAB.: In moist grassy wood-trails and open places near brooks, or even in clay-banks by wood-road, in deciduous woods, oak and chestnut predominating. July, August, and September.

DISTRIB.: New York, *Peck* (Long Island), *Benedict* (Staten Island); North Carolina, 1000–1400 meters elevation, *Burlingham 1*, 1907 (type); Alabama, *Baker*.

DISTINGUISHING FIELD-MARKS: The reddish-brick-colored zonate pileus with its short coarse pile-like tomentum, the madder-brown color of the mature gills, and the abundant white milk, which is very acrid after being on the tongue a moment. The margin of the pileus is usually marked with darker furrows, possibly from the pressure of the inrolled margin upon the gills. The zones are sometimes obscure, but are more often conspicuous. In the dried plant the tomentum is inconspicuous.

A few specimens of this plant were found August 30, 1904, near Smithtown, on Long Island, by Professor Peck, who from the first was inclined to regard it as an undescribed species. In the following summer one specimen was collected by Benedict on Staten Island. But in 1907 in the "Pink Beds," North Carolina, this was the most abundant mushroom throughout July and August. It is frequently gregarious and sometimes cespitose in habit. I have seen as many as fourteen specimens growing within a few square feet. What has proved by comparison to be the same species was collected in Alabama in November, 1896, by C. F. Baker, but as it was accompanied by no field notes it was then impossible to classify it.

I take pleasure in naming this species *Peckii* in recognition of Professor Peck's extensive work upon the genus *Lactaria*.

The type specimens are in the herbarium of the N. Y. Botanical Garden.

46. LACTARIA ALPINA Peck, Ann. Rep. N. Y. St. Mus. **27**: 96. 1875. [As *Lactarius*.] Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1[1**]: 216. 1898

Pileus fleshy, thin, convex, then plane or depressed in the center, sometimes papillate, fulvous to fulvous-isabelline, azonate, dry, minutely squamulose, especially toward the center, 1.5–4 cm. broad, margin involute, then merely arched, even; gills pallid, then yellowish and pruinose, seldom forking, close, thin, decurrent, narrow; stem of the same color as the pileus, or slightly paler, equal, dry, glabrous, stuffed, becoming hollow, 2–5 cm. long, 3–5 mm. thick; spores white, globose, echinulate, 6.5–8 μ; latex white, unchanging, acrid.

HAB.: Borders of woods. July, August, and September.

DISTRIB.: New York, *Peck*, *Earle 864*; Vermont, *Burlingham 106*, 1906; Maryland, *Banning*; District of Columbia, *Murrill 1491*; Virginia, 914 meters, *Murrill 17*; Alabama, *Earle*.

ILLUST.: Banning, Folio Md. Fungi (at N. Y. St. Museum, Albany), *pl. 79*.

DISTINGUISHING FIELD-MARKS: The small size, the tawny-ochraceous color, the squamulose pileus, and acrid latex. It differs from *Lactaria helva* Fr. in its small size, in the pileus being merely squamulose instead of floccose-squamulose, and in the milk never being watery. It is of about the same size and color as *Lactaria subdulcis* (Pers.) Fr.

47. LACTARIA RUFULA Peck, Bull. Torrey Club **34**: 346. 1907. [As *Lactarius*]

Pileus fleshy, firm, broadly convex, becoming somewhat infundibuliform, without an umbo, brownish-red, azonate, dry, apparently glabrous, 5–10 cm. broad; gills pinkish-yellow, becoming darker with age and pruinose, close, adnate; stem colored like the pileus but paler, equally or slightly tapering upwards, sometimes with root-like extension, often with yellowish-brown strigose hairs at the base, stuffed, 4–8 cm. long, 5–6 mm. thick; spores creamy-white, globose, verruculose, 8–10 μ; latex white, acrid.

HAB.: Rich soil and leaf-mold under trees. March.

DISTRIB.: California, *Patterson & Nohara*.

This species seems to be separated from *L. rufa* (Scop.) Fr. chiefly in the absence of an umbo, and in a cespitose habit of growth. I have not seen *L. rufa* living, but it seems to me that

L. rufula is so closely related to it as possibly to prove to be only a form. The type specimens are in the herbarium of the N. Y. State Museum at Albany, and the above description has been arranged from them and the original description.

XIV. GRISEAE

Plants rather small, varying in color from ash-gray to nearly black ; pileus dry and covered with a short tomentum or merely squamulose ; latex white, unchanging, and slowly acrid.

Synopsis of species

Pileus 2.5–5 cm. broad in mature plant, ash-gray to brownish-gray.

Azonate, stem glabrous.

Minutely squamulose or unpolished, aromatic. 50. *L. glyciosma.*

Minutely tomentose, no odor. 48. *L. grisea.*

Zonate, stem white-tomentulose. 51. *L. Hibbardae.*

Pileus not over 15 mm. broad in mature plant, blue-black, then zoned with slate-gray or finally with snuff-brown, scabrous-pubescent. 49. *L. Bensleyae.*

FIGURE 14. *Lactaria grisea* Peck. *No. 85*, 1907, *Burlingham.*

48. LACTARIA GRISEA Peck, Ann. Rep. N. Y. St. Mus. **23** : 119. 1873 (separate, 1872). [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. I[1]**: 216. 1898

Pileus fleshy, rather thin, firm at first, then lax, broadly convex, papillate, then depressed in the center, or at length infundibuliform, with or without papilla, varying from slate-gray (*362*) to smoke-

gray (*363*), becoming yellowish with age (putty-colored, *311*), azonate, dry, minutely tomentose, becoming floccose-tomentose, sometimes appearing squamulose to the naked eye, 1–5 cm. broad, margin involute, then spreading, entire; gills white, becoming cream-colored to honey-yellow, and pruinose, seldom forking, close, adnate to slightly decurrent, broader than the thickness of the pileus; stem of the same color as the pileus or paler, nearly equal, dry, glabrous except at the base, which is sometimes pubescent, stuffed, then hollow, 1.5–6 cm. long, 3–6 mm. thick; flesh white, unchanging, not aromatic; spores white, broadly elliptical, echinulate, 6–7 μ × 8–9.5 μ; latex white, unchanging, slowly acrid. (FIGURE 14.)

HAB.: In moist, mossy places in either coniferous or deciduous woods, on the ground or on decaying logs. July, August, and September.

DISTRIB.: New York, *Peck, Earle, Benedict, Burlingham;* Vermont, *Jones, Burt, Burlingham 2*, 1906; Maine, *White;* Connecticut, *Underwood & Earle, Benedict;* North Carolina, 1000 meters, *Burlingham 85*, 1907.

DISTINGUISHING FIELD-MARKS: The gray, tomentose, azonate, expallent pileus, the glabrous stem, and the lack of odor. While the plants may be dark-gray at first, they usually become dull-yellowish or putty-colored when mature. This species is closely related to *L. mammosa* Fr., a European plant which has not been found in the United States. As figured by Fries, *L. mammosa* is a larger, stouter plant than *L. grisea*, it does not become yellowish with age, and it has a white pubescence on the margin of the young pileus, and the stem is pubescent. *L. grisea* is at first uniformly gray and covered with gray tomentum, which later becomes floccose and less evident.

49. LACTARIA BENSLEYAE Burl. Bull. Torrey Club **34**: 87. 1907.

[As *Lactarius*]

Pileus fleshy, firm, nearly flat with margin inrolled, papillate, when older depressed in the center but the margin still recurved, blue-black when young and moist, then zoned with slate-gray (*362*), and finally with snuff-brown (*303*) toward the margin, the center remaining nearly black, dry, surface covered with a dense, minute, short, rather stiff pubescence, 2–15 mm. broad; gills whitish, some forking near the stem, close, slightly decurrent, 1 mm. wide or equal to the thickness of the pileus, stem somewhat

buff or putty-colored (*311*), covered more or less with a gray pruinosity, nearly equal, dry, glabrous, becoming hollow, 1 cm. or less in length, 2–3 mm. thick; flesh of the pileus gray, of the stem buff; spores slightly cream-colored, mostly globose, some slightly elliptical, echinulate, 5–6.5 μ, or rarely 6.5–8 μ; latex white, unchanging, acrid.

HAB.: Woods, in black moist soil, under yellow birch and spruce trees. July to September.

RANGE: Vermont, 500 meters, *Bensley, Burlingham.*

DISTINGUISHING FIELD-MARKS: The blue-black color of young or wet plants, the minute size, the hirsute-downy covering of the pileus, and the distinct zonation in the mature pileus. The species is gregarious in habit and is sometimes cespitose. As many as 35 were found in the type collection growing in an area of less than one square foot. As a rule, the stem is so short that the pileus rests upon the ground, and the plants can be detected only by careful search. Type specimens of this species are in the herbarium of the N. Y. Botanical Garden and in the herbarium of the N. Y. State Museum at Albany. They are *no. 38*, 1906.

50. LACTARIA GLYCIOSMA (Fr.) Fr. Epicr. 348. 1838. [As *Lactarius.*]—Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 538. 1889

Agaricus glyciosmus Fr. Obs. Myc. **2**: 194. 1818.

Pileus fleshy, thin, convex, then expanding, umbonate, at length depressed, often without umbo, varying from dark-gray (*361*) to gray (*359*) and snuff-brown (*303*), azonate, dry, "slightly innately-squamulose, or unpolished," 2–5 cm. broad, margin involute, then spreading and striate; gills straw-colored, becoming ochraceous, close, slightly decurrent, 2 mm. broad; stem of the same color as the pileus or paler and more yellowish, nearly equal, dry, glabrous or minutely downy, stuffed, becoming hollow, 2–5 cm. long, 4–8 mm. thick; flesh white, odor strong, aromatic; spores white, globose to broadly elliptical, echinulate, 6–7 $\mu \times$ 6–8 μ; latex white, unchanging, slowly acrid.

HAB.: In woods, on the ground or on decaying wood. August, September, and October.

DISTRIB.: New York, *Peck;* Vermont, *Jones;* Missouri, *Glatfelter 1203.*

ILLUST.: Britz. Lact. *f. 29* (poor); Cooke, Br. Fungi, *pl. 1011;*

Fries, Icon. *pl. 170. f. 3* (good); Krombh. Abbild. *pl. 39. f. 16–18* (poor, doubtful).

EXSIC.: Karsten, Fungi Fennici *307*; Herpell, Sammlung präparirter Hutpilze *47*.

DISTINGUISHING FIELD-MARKS: Although this is much the same color as *L. grisea*, it can readily be distinguished from it by the absence of tomentum, by the striate margin, and the pungent, aromatic odor, which persists for some time. The pileus is only faintly squamulose, and sometimes seems to be merely roughened and unpolished. It is never floccose-squamulose like the pileus in mature forms of *L. grisea*.

According to Fries, the color is sometimes brick-red and again has a violet tinge, but this has not been observed in the American forms.

51. LACTARIA HIBBARDAE Peck, Jour. Myc. **14**: 2. 1908. [As *Lactarius*]

Pileus fleshy, broadly convex or nearly plane, with or without an umbo, grayish-brown tinged with pink, darker and smoother in the center, slightly zonate, dry, minutely tomentose or pubescent, 1.5–2.7 cm. broad, margin thin, even, sometimes wavy; gills cream-colored, some forking, close, adnate, thin, narrow; stem pinkish-white, equal or slightly tapering upwards, glabrous below, whitish-tomentose at the top, stuffed, 2.5–4 cm. long, 3–6 mm. thick; flesh whitish, odor weak or none; spores globose, 6–8 μ; latex white, unchanging, acrid. (Arranged from Peck's description.)

HAB.: On the ground under pine trees. October.

DISTRIB.: Massachusetts, *Hibbard*.

DISTINGUISHING FIELD-MARKS: This species may be distinguished from *L. glyciosma*, which it most closely resembles, by the tomentose rather than squamulose pileus, the faint zonation, the absence of the odor peculiar to that plant, and by the tomentum on the stem.

The type specimens are in the herbarium of the N. Y. State Museum at Albany.

XV. PLINTHOGALAE

Pileus dry, pruinose to velvety, dark-brown, smoky-brown, or putty-colored to paler, flesh rather firm, plants of medium size; gills becoming darker with age, and pruinose; latex mild or acrid,

salmon-colored or white, either unchanging or changing to salmon-pink, at least where in contact with the broken flesh, or in one species becoming yellow.

The species in this group show as close a relationship as do those in the *Lactifluae*. Three of the species seem to be limited to America.

Synopsis of species

Latex or wounds becoming salmon-pink or reddish.	
Pileus azonate, unspotted, no odor.	
Pileus dark-brown, velvety.	54. *L. ligniota.*
Pileus snuff-brown or paler, pruinose.	52. *L. plinthogala.*
Pileus spotted, odor bad.	*L. acris.**
Latex and wounds not changing color.	
Spores yellow.	53. *L. Sumstinei.*
Spores white.	55. *L. Gerardii.*
Latex becoming yellowish.	
Pileus subtomentose.	56. *L. subtomentosa.*
Latex salmon-colored from the first, pileus whitish.	57. *L. salmonea.*

52. **Lactaria plinthogala** (Otto)

Agaricus azonites Bull. Hist. Champ. **2**: 497. 1809; Herb. Fr. *pl. 567. f. 3.* 1791. Probably not *Lactarius azonites* Gillet.

Agaricus plinthogalus Otto, Versuch Agar. 75. 1816.

Agaricus fuliginosus Fr. Syst. Myc. **1**: 73. 1821.

Lactarius fuliginosus Fr. Epicr. 348. 1838.

Lactarius fumosus Peck, Ann. Rep. N. Y. St. Mus. **24**: 74. 1872.

Lactariella azonites (Bull.) Schröt. in Cohn, Krypt.-Fl. Schles. **3**: 544. 1889.

Pileus fleshy, convex then plane, sometimes with a small umbo, depressed in the center, then subinfundibuliform, raw-umber to a dingy yellow-brown (*323, café au lait*), snuff-brown (*303. t. 4*) or putty-colored (*311*) to pallid, usually darker in the center and at first, then fading, dry, glabrous, but covered with a bloom, very smooth, sometimes slightly wrinkled in the center when mature, 2–6.5 cm. broad, margin entire or wavy; gills nearly white at first, then maize-yellow (*36. t. 4*), becoming pinkish or salmon where wounded (*74. t. 1*), pruinose, sometimes forking near the stem, sometimes connected by vein-like reticulations, subdistant, adnate or slightly decurrent, about 5 mm. broad; stem of the same color as the pileus, often whitish toward the base, nearly equal or tapering downwards, glabrous, pruinose, stuffed but firm, then hollow,

* European species, the occurrence of which in the United States is doubtful.

3–7 cm. long, 6–12 mm. thick; flesh white, changing to reddish or salmon where exposed to the air; spores yellow, mostly globular, echinulate, uniguttulate, 6.5–10 μ; latex white, rarely changing color except where in contact with the flesh, where it becomes salmon-pink, mild, then acrid.

HAB.: In deciduous or mixed woods. July to September.

DISTRIB.: New York, *Peck*, *Earle*, *Peck & Earle* (Long Island); Maine, *White*; Vermont, *Burlingham 41*, 1906; Pennsylvania, *Murrill*, *Herbst*; North Carolina, *Burlingham 80*, 1907. It has also been reported from Alabama by Atkinson.

ILLUST.: Atkinson, Stud. Am. Fungi, *f. 117*; Bern. Champ. Roch. *pl. 38. f. 3*; Britz. Lact. *f. 33*^{a}, *40*; Bull. Herb. Fr. *pl. 567. f. 3*; Cooke, Br. Fungi, *pl. 996*; Gillet, Champ. Fr. *pl. 165* [*384*]; Harzer, Pilze, *pl. 19*; Krombh. Abbild. *pl. 14. f. 10–12* (*f. 12* very poor); Noulet & Dass. Champ. *pl. 18. f. B.*; Pat. Tab. Analyt. Fung. *pl. 322.*

EXSIC.: Herpell, Sammlung präparirter Hutpilze *13*.

DISTINGUISHING FIELD-MARKS: For the most part, the pileus is snuff-brown or coffee-and-milk-colored, and is dry, glabrous or pruinose, and very smooth; the gills become yellow and the spores are yellow, while wounds of the plant become salmon-pink or reddish. The species varies greatly in size, color, closeness of the gills, and in the readiness with which the latex or wounds change color.

In the "Pink Beds," North Carolina, I found small forms growing in moss and shade, having the pileus nearly white, or stone-colored in the center, and from 3–4 cm. broad, and the gills white, close, and about 2 mm. broad, while the latex as well as the wounds became salmon-pink, but since intergrading forms occur it does not seem possible to separate it from the species. At the other extreme, in sandy soil, large normally colored forms occurred, having distant gills up to 10 mm. broad, the wounds changing slowly but the latex unchanging except where in contact with the flesh. As a rule, the paler the plant, the more quickly the wounds become salmon and the more likely the milk is to change color. The small white form described above, *no. 60*, 1907, and the distant-gilled form, *no. 69*, 1907, are in the herbarium of the N. Y. Botanical Garden.

Gillet considered *Agaricus azonites* Bull. *pl. 559* to be the type of a distinct species from *Lactaria fuliginosa* Fr. and accordingly described a *Lactarius azonites* based on that plate as the type.

53. LACTARIA SUMSTINEI Peck, Bull. Torrey Club **32** : 78. 1905. [As *Lactarius*]

Pileus fleshy, rather thin, firm, convex, soon depressed in the center, grayish to putty-colored (*311*), azonate, dry, glabrous, smooth, or with wrinkles radiating from the center, 2.5–7.5 cm. broad, margin involute, then arched or spreading; gills colored like the pileus, distant, thin, decurrent, 1 cm. or more broad; stem colored like the pileus, nearly equal, rather firm, dry, glabrous, 2.5–5 cm. long, 6–12 mm. thick; flesh whitish, not discolored with the milk; spores yellow, globular, echinulate, 7.5–10 μ; latex white, unchanging, and not staining the flesh or gills, acrid.

HAB.: "Grassy places in open woods." In deciduous woods. July and August.

DISTRIB.: Pennsylvania, *Sumstine* (type); District of Columbia, *Murrill 1476* and *1523*; Virginia, *Murrill 1682*; Missouri, *Glatfelter 1077*.

DISTINGUISHING FIELD-MARKS: The grayish or yellowish-gray color of the entire plant, the glabrous, dry pileus, and the unchanging acrid white milk. Wounds of the gills and flesh do not become pinkish or salmon as in *L. plinthogala*. It differs from *L. Gerardii* in its paler color, its yellow spores, in the gills being of the same color as the pileus, and in the acrid taste of the latex.

The type specimens are in the herbarium of the Carnegie Museum at Pittsburg, Pa., and in the herbarium of the N. Y. St. Museum at Albany.

54. LACTARIA LIGNIOTA [illegible] Monogr. **2** : 177. 1863. [As *La[illegible]rius*]

Lactarius fuliginosus majo[illegible] F[illegible]icr. 348. 1838.

Lactariella ligniota Schr[illegible] Cohn, Krypt.-Fl. Schles. **3** : 544. 1889.

Pileus fleshy, convex, [illegible] to slightly depressed, umbonate, often wrinkled in th[illegible], dark-brown, azonate, dry, pruinose-velvety, 3–8 cm. bro[illegible] [illegible]gin sometimes plicate; gills white to ochraceous, becomin[illegible] or salmon where wounded, not crowded, of various lengths, [illegible]nt, about 5 mm. broad; stem

of the same color as the pileus, equal or abruptly smaller and plicate at the apex, smooth, pruinose-velvety, stuffed, up to 8 cm. long and 12 mm. thick; flesh white, becoming pinkish or salmon where wounded; spores yellowish, globular, echinulate, 9–10 μ; latex white, changing to salmon-pink where in contact with the broken flesh, mild or finally slightly acrid.

HAB.: On the ground in mossy wet woods, especially fir. July to September.

DISTRIB.: New York, *Peck*; Vermont, *Burlingham 43*, 1906, *Jones*; Connecticut, *Hammer 1945*; New Jersey, *Sterling*; North Carolina, *Burlingham 20*, 1907.

ILLUST.: Atkinson, Stud. Am. Fungi, *f. 116*; Britz. Lact. *f. 4*; Fr. Icon. *pl. 171. f. 1.*

DISTINGUISHING FIELD-MARKS: This species differs from *Lactaria fuliginosa* in its darker seal-brown color, the velvety covering of the pileus and stem, the more rugose surface of the pileus, and in the larger average size of the plant.

Peck has described one "variety" under this species, *L. ligniota tenuipes*, which differs in the small size and the slender stem. This form has been found also in Connecticut by *Hammer 1479*, and in Vermont I found one specimen, *43*, 1906, growing from an old stump in spruce woods. The form *tenuipes* may be characterized as follows:

Pileus up to 3 cm. broad, stem 2.5–8 cm. long, 4 mm. thick.

55. LACTARIA GERARDII Peck, Ann. Rep. N. Y. St. Mus. **26**: 65. 1874.* [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**[1**]: 216. 1898

Pileus fleshy, firm, convex at first, often with a small umbo, then plane or depressed, dark seal-brown, becoming golden-brown or umber, or sometimes paler, azonate, dry, surface velvety, rugose radiately from the center, sometimes becoming cracked near the margin, margin even or wavy and irregular, often paler in color, thin, becoming extended; gills white then cream-colored, more or less interveined, distant, appearing more so in older specimens with somewhat irregular spaces, decurrent, not very thin, broad; stem the same color as the pileus, velvety to the touch, equal or ventricose, stuffed, then hollow, 2.5–5 cm. long, 4–20 mm. thick; flesh white, unchanging; spores white, globular, echinulate, 6.5–9 μ; latex white, unchanging, mild, then slightly acrid. *Edible.*

* Separate published in advance in April 1874.

HAB.: On the ground in woods or in open groves. July to September.

DISTRIB.: New York, *Gerard*, *Peck*, *Earle*, *Burlingham*, *Peck & Earle* (Long Island); Vermont, 600 meters, *Burlingham 28*, 1906; Pennsylvania, *Murrill;* District of Columbia, *Murrill;* North Carolina, 1000 meters, *Burlingham 23*, 1907.

ILLUSTR.: Ann. Rep. N. Y. St. Mus. **26**: *pl. 59. f. 12–16;* Memoir N. Y. St. Mus. **3**: *pl. 53. f. 12–16.*

DISTINGUISHING FIELD-MARKS: This species is closely related to *Lactaria ligniota* Fr., but can be distinguished from it by the white spores, the unchanging color of the broken flesh or gills, and the more distant gills.

The type specimens were collected near Poughkeepsie, N. Y., by W. R. Gerard, in whose honor the mushroom is named. They are preserved in the herbarium of the N. Y. State Museum at Albany.

56. LACTARIA SUBTOMENTOSA Berk. & Rav. Ann. and Mag. Nat. Hist. III. **4**: 11. 1859. [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**^{1**}: 216. 1898.

Pileus convex, firm, umber-brown, dry, subtomentose, 5–7.5 cm. broad; gills white, distant, decurrent, broad; stem of the same color as the pileus except at the white base, hollow, 2.5 cm. long, 12 mm. thick; latex white, becoming yellowish, acrid.

HAB.: On the ground in swamps. September.

DISTRIB.: South Carolina, *Ravenel.*

DISTINGUISHING FIELD-MARKS: The dry umber-brown, subtomentose pileus, and the acrid white latex, which becomes yellow on exposure to the air.

I have not seen the type specimens of this species, which are in the herbarium of the Royal Botanic Gardens at Kew. But the species seems to be well defined and distinct from any other of our species, and it is probable that further collections in South Carolina may discover more of these plants.

57. LACTARIA SALMONEA Peck, Bull. Torrey Club **25**: 369. 1898. [As *Lactarius*]

Pileus fleshy, rather firm, thin, convex, soon depressed in the center, otherwise nearly plane, white, becoming reddish where

bruised, dry, somewhat velvety, 2.5–3.8 cm. broad, margin involute, then spreading, even; gills pallid, becoming darker, brownish in drying, close, adnate to decurrent; stem white, salmon-colored within, nearly equal, occasionally eccentric, velvety, solid, about 2.5 cm. long, 3–6 mm. thick; flesh becoming salmon where wounded; spores subglobose, echinulate, 7.5–9 μ; latex salmon-colored.

HAB.: In wet swampy places, usually on naked ground that has been overflowed. August to October.

DISTRIB.: Alabama, *Earle* (type); Mississippi, *Earle*.

DISTINGUISHING FIELD-MARKS: The white color of the plant, the velvety covering, the short stem, and the salmon-colored latex.

This is the only known species having from the first salmon-colored milk. I have not seen this plant living and I am in doubt as to its relationship. The dry velvety pileus and the salmon color assumed by wounds would indicate a relationship with the *Plinthogalae*, while the colored milk would tend to place it with the *Dapetes*.

DOUBTFUL SPECIES

LACTARIA ACRIS (Bolt.) Fr. Epicr. 342. 1838. [As *Lactarius*.]
— Hennings, in Eng. & Prantl, Nat. Pflanzenfam.
1[1]**: 216. 1898

This European species has been reported from North Carolina by Schweinitz in Syn. Fung. Carol. Super. 60. 1818, but the specimens have been destroyed by insects, and, since this is the only station for which it has been reported, I hesitate to include it in the list of species positively known in the United States. Its relationship seems to be with *Lactaria plinthogala*. The distinguishing marks are the ill odor, the spotted pileus, and the more reddish color assumed by the acrid latex. It is well figured in Cooke, Br. Fungi, *pl. 1005*.

XVI. LACTIFLUAE

Pileus dry, glabrous or velvety, some shade of fulvous, flesh rather thick and firm; gills becoming darker with age and pruinose; latex abundant, sweetish or at least mild, unchanging, but the gills and flesh sometimes becoming brown where injured.

The members of this group seem to be very closely related, the species, in one instance, differing chiefly in the reaction of the wounds upon exposure to the air. With the exception of the first two, the species are all confined to America.

Synopsis of species

Pileus entirely glabrous.
- Azonate. — 58. *L. lactiflua.*
- Zonate. — 60. *L. ichorata.*

Pileus pruinose-velvety.
- Gills not staining brown where injured.
  - Distant. — 59. *L. hygrophoroides.*
  - Close. — 63. *L. subvelutina.*
- Gills staining brownish where injured.
  - Pileus yellowish-buff, smooth or very slightly rugose. — 62. *L. luteola.*
  - Pileus Vandyke-brown to dead-leaf, usually corrugated. — 61. *L. corrugis.*

58. **Lactaria lactiflua** (L.)

Agaricus lactifluus L. Sp. Pl. 1172. 1753.
Agaricus oedematopus Scop. Fl. Carn. **2**: 453. 1772.
Agaricus testaceus Alb. & Schw. Consp. Fung. 209. 1805.
Agaricus volemus Fr. Syst. Myc. **1**: 69. 1821.
Lactarius volemus Fr. Epicr. 344. 1838.

Pileus fleshy, firm, convex, then nearly plane or slightly depressed, fulvous (*308*), buff (*309*), brownish-terra-cotta (*334*) to brownish-orange, sometimes much paler, azonate, dry, glabrous, smooth or at length rimose-rivulose, 5–13 cm. broad when mature; margin even, involute at first, then extended; gills creamy-white, or tinged with the same color as the pileus, becoming darker with age, changing brownish where injured, often forking 2 or 3 mm. from the stem or midway to the margin, close, adnate, 2–5 mm. broad; stem of nearly the same color as the pileus but paler, nearly equal, glabrous, pruinose, solid or sometimes becoming hollow, 2–10 cm. long, 1–2 cm. thick; flesh whitish, changing brown where exposed to the air, odor strong, persisting; spores white, globular, echinulate, 7–10 μ, cystidia 20–35 μ long, colorless or yellowish; latex white, unchanging, mild, sticky, abundant. *Edible.*

HAB.: In woods or groves, especially in the vicinity of oaks. July to October.

DISTRIB.: New York, *Peck, Earle, Burlingham 23*, 1904; Maine, *White, Murrill;* Vermont, *Jones, Burlingham;* Massachusetts, *Morris;* Connecticut, *Earle, Underwood, Hanmer;* New Jersey, *Ellis;* Pennsylvania, *Herbst;* Maryland, *Banning;* District of Columbia, *Murrill;* North Carolina, *Atkinson, Burlingham 14*, 1907, 1,000–1,400 meters elevation; Virginia, *Murrill;* Ala-

* See also "Doubtful Species."

bama, *Baker*, *Earle*, *Underwood*; Mississippi, *Earle*; Ohio, *Beardslee*; Missouri, *Glatfelter 1078*; Indiana, *G. W. Wilson*.

ILLUST.: Barla, Champ. Nice, *pl. 20. f. 1–3*; Bel. Champ. Tarn. *pl. 23*; Boyer, Champ. *pl. 31*; Bres. Fung. Mang. *pl. 66*; Britz. Lact. *f. 6*; Cooke, Br. Fungi, *pl. 999*; Cordier, Champ. Fr. *pl. 26. f. 2*; Ellrodt, *pl. 6. f. 1, 2, 3*; Fr. Sverig. Svamp. *pl. 10*; Gillet, Champ. Fr. *pl. 170* [*402*] (form); Hahn, Der Pilz-Sammler, ed. 2. *pl. 4. f. 14*; Hussey, Illust. Br. Myc. **1**: *pl. 87*; Krombh. Abbild. *pl. 39. f. 1–4* (coloring poor); Lucand, Champ. Fr. *pl. 145*; Peck, Ann. Rep. N. Y. St. Mus. **48**: *pl. 30*; Pat. Tab. Analyt. Fung. *pl. 323*; Rolland, Bull. Soc. Myc. Fr. **7**: *pl. 2. f. 1*; Roumeg. Crypt. Illust. *pl. 142*; Rich. & Roze, Atl. Champ. *pl. 38. f. 6–12* (coloring poor); Schaeff. Fung. Bav. Icon. *pl. 5*; Sicard, Hist. Nat. Champ. *pl. 44. f. 236* (poor); Venturi, Studi Micol. *pl. 6. f. 42–48*; White, Conn. Geol. and Nat. Hist. Surv. Bull. **3**: *pl. 10*.

EXSIC.: Herpell, Sammlung präparirter Hutpilze *14*; Roumeguère, Fungi Selecti Exsic. *5223*; Sydow, Mycotheca Marchica *608*; Thümen, Fungi Austriaci *812*.

DISTINGUISHING FIELD-MARKS: The rather large size and thick flesh of the plant, the glabrous, smooth, or sometimes rugose or cracked surface of the pileus, the fulvous to golden-fulvous color of both pileus and stem, the whitish gills which become brown where injured and in drying, and the abundant, mild, sticky latex. The latex drops from even slight wounds in the gills or flesh.

There is a great variation in color in different specimens of *L. lactiflua*, but the other characteristics remain so constant that it seems scarcely possible to separate valid varieties upon the color basis. Two collections from Virginia (*407* and *266* Murrill) are described as pale cream-color, while in North Carolina I found the color varying from pale-buff to a dark chestnut-red (Indian chestnut-red, *333*). This difference in color does not seem to be due to a shady or a sunny habitat. The rugose and the cracked character of the pileus, however, is probably due to weather conditions or to moisture content. In wet weather the pileus is more often rugose, while in dry weather the surface is liable to become cracked in areas. In North Carolina, while rain fell nearly every day the rugose condition prevailed, the plants with the cracked

pileus being found only later in the season when the weather was drier. Consequently, the forms having a rugose pileus I would include as merely a normal variation of the species.

Linnaeus describes *Agaricus lactifluus* "*pileo plano carneo lactescente, lamellis ruffis, stipite longo carneo.*" This is rather brief to indicate plainly the type that he was describing, but he cites Haller's "*Fungus flavo-ruffus in medio depressus, lacte non acri manans*" as synonymous with *Agaricus lactifluus.* Haller's description applies without doubt to *L. volema* Fr. He says "not rare in forests, easily recognized from its smoothness, firm flesh, sweet milk such as is rare in fungi. In shape the pileus is elegantly depressed in the center, with the margin roundly elevated. The color is everywhere rufus-flavous, butyraceous, lamellae paler. Not decaying, but becoming coriaceous. It is edible, with good taste. Ours is occasionally 4 in. in diameter." (Haller, Helv. 50. 1742.) Lamarck in Fl. Fr. 1 : 106. 1748, describes *Agaricus lactifluus* of Linnaeus in terms which show his plant to have been *L. volema* Fr., and he cites Schaeff. *pl. 5.* The gills of *L. volema* Fr. become rufous with age or in drying so that there is nothing in Linnaeus' description which disagrees with this species; and from his citation there seems to be little doubt that his plant was identical with *L. volema* Fries.

Agaricus oedematopus Scop. does not seem to differ from *L. volema* Fr. and the description by Scopoli agrees more exactly with Fries' description of *L. volema* than it does with the "variety" *oedematopus.* And from Scopoli's description I have referred *Agaricus oedematopus* to *L. lactiflua* (L.), or *L. volema* Fr.

59. LACTARIA HYGROPHOROIDES Berk. & Curt. Annals and Mag. Nat. Hist. III. 4: 10. 1859. [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1^{1**} : 214. 1898

Lactarius distans Peck, Ann. Rep. N. Y. St. Mus. 23: 117. 1873. [Separate in April, 1872.]

Pileus fleshy, firm, convex, then plane, depressed in the center, sometimes becoming infundibuliform, yellowish-buff (*310*), bistre (*328*), or fulvous (*308*), azonate, dry, very minutely pruinose-velvety, appearing as though pulverulent, sometimes rugose, sometimes rimose-areolate, 4–10 cm. broad, margin involute, then spread-

ing or uplifted ; gills whitish to cream-colored or yellowish-buff, not discoloring where injured, not forking, distant, sometimes connected by rugose elevations, adnate to slightly decurrent, about 3 mm. broad ; stem of the same color as the pileus, nearly equal, glabrous or pruinose, stuffed or solid, 2–5 cm. long, 0.5–1.5 cm. thick ; flesh whitish, no odor ; spores white, globose to broadly elliptical, minutely echinulate, 8–10 μ ; latex white, unchanging, not staining the gills or flesh brownish, mild, not so abundant as in *L. lactiflua* (L.). *Edible.*

HAB. : Mixed woods. July, August, and September.

DISTRIB. : Maine, *Sprague* (type collection) ; New York, *Peck, Underwood, Earle ;* Massachusetts, *Francis ;* Connecticut, *Earle 940 ;* Delaware, *Jackson ;* District of Columbia, *Murrill 1487 ;* Indiana, *G. W. Wilson ;* Missouri, *Glatfelter ;* Mississippi, *Earle.*

ILLUST. : Peck, Mem. N. Y. St. Mus. 3 : *pl. 53. f. 7–11.*

DISTINGUISHING FIELD-MARKS : The yellowish-buff or fulvous color of the plant, the pruinose-velvety covering of the pileus, the usually short stem, the distant gills, which do not stain brown where injured or in drying, and the white, mild latex.

The type specimens of *Lactaria hygrophoroides* are in the herbarium of Harvard University and also of the Royal Botanic Gardens, Kew, England. They are *no. 6194* of Curtis's fungi. Specimens of *Lactarius distans* Peck from the herbarium of the N. Y. Botanical Garden, *no. 940*, were sent to Kew Gardens for comparison with the type specimens of *L. hygrophoroides* and were pronounced by Mr. Massee to agree with the type.

60. LACTARIA ICHORATA (Batsch) Fr. Epicr. 345. 1838. [As *Lactarius.*] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1^{1**} : 274. 1898

Agaricus ichoratus Batsch, Elench. Fung. 38. 1783.

Pileus fleshy, rather thin but opaque, rigid, then lax, plane to depressed in the center, fulvous, sometimes brown in the center, zoned with testaceous, dry, glabrous, smooth, 5–8 cm. broad, margin incurved, then spreading ; gills white, then ochraceous, often forked toward the margin of the pileus, rather close, adnate, not very broad ; stem of the same color as the pileus or more yellowish, dry, glabrous, spongy-stuffed, 5–8 cm. long, eccentric ; flesh pallid, becoming sordid-fuscous when exposed to the air ; spores 8–10 $\mu \times$ 6–7 μ ; latex white, mild or sometimes astringent.

HAB.: On ground in woods.

DISTRIB.: Ohio, *Lloyd.* Rare.

ILLUST.: Batsch, Elench. Fung. *pl. 13. f. 60. a, b;* Britz. Lact. *f. 36* (coloring poor); Cooke, Br. Fungi, *pl. 1000* (good).

DISTINGUISHING FIELD-MARKS: This specimen resembles *L. volema* but differ in being zonate and more slender. Lloyd says of the specimens which he found: "Stem solid but slightly spongy, eccentric in the few specimens I saw. Pileus brown, marked with zones. Milk white, acrid, not changing in color."

These specimens are in the herbarium of the N. Y. State Museum at Albany. In the dried condition they resemble *L. lactiflua* except for the zonation and their smaller size.

61. LACTARIA CORRUGIS Peck, Ann. Rep. N. Y. St. Mus. **32**: 31. 1880. [As *Lactarius.*] Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**[1**]: 214. 1898

Pileus fleshy, firm, thick, convex, then depressed in the center, color varying from Vandyke-brown (*340. t. 4–1*) in the center, to mineral-brown (*339. t. 1*) at the margin, sometimes paler, approaching more nearly dead-leaf (*321. t. 1*), azonate, dry, minutely velvety, and appearing as though covered with a bloom, surface more or less corrugated, 7–12 cm. broad, margin involute at first, then arched or spreading; gills cinnamon (*323. t. 3*) when young, paler when mature or tinted with honey-yellow, becoming fulvous-brown where injured or when dried, sometimes forking, close, adnate to slightly decurrent; stem tinted with dead-leaf (*321. t. 1*), paler than the pileus, nearly equal, dry, pruinose in the upper portion, minutely pubescent at the base, firm, solid, 6–7 cm. long, 2–2.5 cm. thick; flesh white, having only a slight odor; spores white, globose, echinulate, 9–12 μ; latex white, unchanging, mild or slightly astringent, abundant. *Edible.*

HAB.: Moist woods, especially in mixed oak-chestnut-maple woods. August and September.

DISTRIB.: New York, *Peck;* Connecticut, *Webster, Underwood, Hanmer, 1936;* New Jersey, *Sterling;* Pennsylvania, *Herbst;* Delaware, *Jackson;* North Carolina, *Atkinson, Burlingham 18*, 1907 (1000 meters); Tennessee, *Murrill, 596;* Alabama, *Earle;* Mississippi, *Earle;* Missouri, *Glatfelter.*

ILLUST.: Atkinson, Stud. Am. Fungi, *f. 115.*

DISTINGUISHING FIELD-MARKS: The rather large size of the ma-

ture plants, the dark color of the pileus, which inclines more to Vandyke-brown than to fulvous, the paler stem, the velvety-pubescent covering of the pileus and the lower portion of the stem, and the more or less corrugated condition of the pileus. There is but little or no odor, and the wounds of the gills do not turn brown so quickly as in *L. lactiflua.*

The species is closely related to *L. lactiflua.* The specific name refers to the corrugated surface of the pileus, but since *L. lactiflua* occurs with a rugose pileus, the specific differences seems to me to be in the velvety-pubescent covering of *L. corrugis*, the more livid color of the plant, the absence of the strong odor which is characteristic of *L. lactiflua*, and the larger spores and cystidia. As a rule the cystidia of *L. lactiflua* are paler.

62. LACTARIA LUTEOLA Peck, Bull. Torrey Club **23**: 412. 1896.
[As *Lactarius*]

Lactarius foetidus Peck, Bull. N. Y. St. Mus. **54**: 949. 1902.

Pileus fleshy, firm, broadly convex or nearly plane, somewhat depressed in the center, whitish to yellowish-buff (*3 10*), azonate or sometimes with a depressed zone near the margin, dry, minutely pruinose-velvety, sometimes slightly rugose, 5–8 cm. broad, margin involute at first, then arched or spreading; gills white, then yellowish, becoming brown where injured, some forking near the stem, close, adnate, or slightly decurrent, narrow; stem of the same color as the pileus, nearly equal, dry, somewhat pruinose-velvety, stuffed, 2–6.5 cm. long, 6–12 mm. thick; flesh whitish, staining brown where injured; spores white, subglobose, echinulate, 7.5–8 μ; latex white, staining the flesh and gills brown, mild, abundant.

HAB.: Mixed woods, among fallen leaves, in dry or fairly moist soil. July, August, and September.

DISTRIB.: Massachusetts, *Webster* (type specimens); New York, *Peck, Earle 840;* Connecticut, *Hanmer 534;* Tennessee, 518 meters, *Murrill 960;* Ohio, *Beardslee;* Missouri, *Glatfelter;* Mississippi, *Earle.*

ILLUST.: Bull. N. Y. St. Mus. **67**: *pl. 83. f. 7–11.*

DISTINGUISHING FIELD-MARKS: The whitish to yellowish-buff color of the pileus and stem, the minutely velvety covering, and the white, close narrow gills which stain brown where wounded. The latex is very abundant, and according to Peck becomes brown

upon exposure to the air. The color of the plant becomes a deeper yellow in drying. It may be distinguished from *L. lactiflua* by its smaller size, the velvety, more yellow pileus, and by the different odor. It resembles *L. hygrophoroides* more closely, but can be separated from that by the close gills, and by the brown color which the milk and wounds assume.

After further collections of *L. luteola*, Professor Peck now considers *L. foetidus* Peck to be the same species, having found that *L. luteola* sometimes has a fetid odor; accordingly, *L. foetidus* is reduced to a synonym. The type specimens are in the herbarium of the N. Y. State Museum at Albany.

63. LACTARIA SUBVELUTINA Peck, Bull. N. Y. St. Mus. **75**: 18. 1904. [As *Lactarius*]

Pileus fleshy, firm, convex then nearly flat, depressed in the center, golden-fulvous, dry, minutely velvety, appearing pruinose to the naked eye, sometimes wrinkled, 2.5–5 cm. broad, margin inrolled, then spreading, even, sometimes wavy; gills cream-colored, becoming darker with age, not staining brown where injured, a few forking, close, adnate to slightly decurrent, narrow; stem of the same color as the pileus or paler, equal, somewhat velvety, smooth, solid, 1–2 cm. long, 4–8 mm. thick; flesh white, not staining brown; spores white, subglobose, nearly smooth (minutely and sparsely papillate), 6.5–8 μ; latex white, unchanging, mild.

HAB.: "Woods and open places."

DISTRIB.: New York, *Peck* (type); Ohio, *Dawson 41*; Missouri, *Glatfelter 399*.

DISTINGUISHING FIELD-MARKS: The close gills and the unchanging white latex which does not stain the gills brown.

The dried specimens of this plant closely resemble those of *L. luteola* Peck, but the spores are smaller and smoother.

DOUBTFUL SPECIES

"LACTARIUS SACCHARIUM" Johnson, Bull. Minn. Acad. Sci. 1878: 337. 1878.

The type spcimens of this species I have not seen, and, so far as is known, Johnson's material from which he made his determinations has not been preserved. Since the type is not available and

since during the thirty years following the description no further collections have been reported, I hesitate to regard it as a valid species. But in order that the species may be established if it be valid, I append the following, arranged from Johnson's description :

Pileus convex, papillate, at length expanded, depressed, then infundibuliform, brownish, or slate, pruinose, then reddish-orange, 1.5–4 cm. broad ; gills pale-orange, becoming brownish when old, dimidiate or entire, sinuate, crowded, decurrent, narrow ; stem orange, irregular, compressed, curved or straight, 1.5 cm. high, 2–6 mm. thick ; latex white, slightly sweet. The plants are gregarious, or cespitose. The pileus and the upper part of the stem are milky, but the gills are not. It was found growing among moss and grass, beneath poplar trees. July and August.

LACTARIA CALCEOLUS Berk. Lond. Jour. Bot. 6 : 315, 316. 1847.

[As *Lactarius*]

Pileus fleshy, thin, convex, with depressed center, brown-buff, dry, smooth, 7.5 cm. broad, margin repand, epidermis rimose ; gills white, more or less connected by transverse veins, forked near the edge, very distant, decurrent, up to 12 mm. broad ; stem of the same color as the pileus, 12 mm. thick and long ; flesh white ; latex white, mild.

HAB. and LOC. : On the ground in woods, Waynesville, Ohio, August 31 and September 10, 1844, *T. G. Lea.*

Berkeley says : "An extremely curious species, remarkable for its few distant gills and the contrast between them and the brown-buff stem. The pilei in all the specimens found at present are laterally confluent. It cannot be confounded with any known species."

This species has not been reported since they were collected by Mr. Lea, and the confluent pilei would indicate them to be an abnormal growth, very possibly of *L. hygrophoroides*, described by Berkeley & Curtis in 1859 from Sprague material.

XVII. CAMPHORATAE

Pileus dry, glabrous, usually smooth and polished, but sometimes becoming areolate or minutely roughened with pits, reddish-brown, fulvous, or tawny, rarely grayish, plants not large, pileus thin, flesh lax ; gills becoming darker with age and pruinose ; latex mild or tardily acrid, white, or thin and watery, usually unchanging.

Synopsis of species

Latex white, unchangi ng.
Odor aromatic in drying, pileus red-brown. 64. *L. camphorata.*
Odor none.
Pileus azonate.
Gills not changing color when wounded.
Fulvous to isabelline, sometimes bay-red. 66. *L. subdulcis.*
Golden-fulvous, stem orange *L. mitissima.*†
Gills becoming greenish where wounded.
Pileus about 3 cm. broad, umber-colored. 70. *L. parva.*
Pileus up to 7.5 cm. broad, grayish, often roughened. 71. *L. varia.*
Pileus zonate when moist, rather large. 69. *L. mutabilis.*
Latex white, becoming yellowish or staining gills yellow, pileus yellowish-buff. 68. *L. isabellina.*
Latex watery or whey-colored.
Pileus brownish-terra-cotta, fading, areolate. 65. *L. rimosella.*
Pileus not becoming areolate.
Margin even. 67. *L. serifiua.*
Margin crenate to sulcate, plant small. 64. *L. camphorata fragilis*

64. LACTARIA CAMPHORATA (Bull.) Fr. Epicr. 346. 1838. [As *Lactarius.*]—Schröt. in Cohn, Krypt.-Fl. Schles. 3: 535. 1889.

Agaricus camphoratus Bull. Herb. Fr. *pl. 567. f. 1.* 1791; Hist. Champ. 493. 1809.

Pileus fleshy, firm, rather thin, convex, often umbonate, at length expanded, depressed in the center, but the margin still arching, fulvous (*308*) to madder-brown (*334*), azonate, dry, glabrous, 1–4 cm. broad, margin inrolled and pruinose at first, not striate; gills whitish or flesh-colored (*67*), becoming reddish-brown, sometimes a few forking next the stem, close, adnate to slightly decurrent, rather narrow; stem of the same color as the pileus or paler, nearly equal, sometimes flexuous, glabrous, pruinose, smooth, firm to spongy, 1–3 cm. long, 3–8 mm. thick; flesh of about the color of the gills, unchanging, odor aromatic, becoming more pronounced in drying; spores white, globose, echinulate, 6–7 μ; latex white, unchanging, mild, abundant. *Edible.*

HAB.: In woods, more abundant in moist mixed woods. July to October.

DISTRIB.: New York, *Peck, Earle, Burlingham;* Massachusetts, *Davis, Morris;* Connecticut, *Earle;* Vermont, *Burlingham 10,* 1906, *Burt;* Pennsylvania, *Glatfelter;* Virginia, *Murrill;*

* See also "Doubtful Species."
† European species, the occurrence of which in the United States is doubtful.

North Carolina, *Burlingham 3*, 1907; Tennessee, *Murrill*; Alabama, *Earle*.

ILLUST.: Barla, Champ. Nice, *pl. 20. f. 11–13* (coloring poor); Bern. Champ. Roch. *pl. 38. f. 2*; Bull. Herb. Fr. *pl. 567. f. 1*; Cooke, Br. Fungi, *pl. 1013. f. a*; Hahn, Der Pilz-Sammler, *f. 12* (coloring poor); Krombh. Abbild. *pl. 39. f. 21–24*; Sicard, Hist. Nat. Champ. *pl. 43. f. 243* (poor); Venturi, Studi Micol. *pl. 13. f. 126* (poor).

DISTINGUISHING FIELD-MARKS: This species is of about the size of *Lactaria subdulcis* and sometimes of nearly the same color, but usually it is a darker-fulvous or more red-brown, and the flesh is firmer. The odor is usually faint at first but becomes strong as it dries. To me the odor is like that of slippery-elm bark. The pileus is polished in appearance and does not fade with age nor become rimulose.

The European writers describe the pileus as zonate, but no zonate specimens have been reported in the United States. In the original description, Bulliard says "*interdum sulcis zonatim exaratus*," which would seem to indicate that the zonation was not marked by a difference in color so much as by concentric wavesor furrows.

In North Carolina I found several times in the same place and once in a different locality plants which were different in several points from the typical *L. camphorata*, but had the characteristic odor both when fresh and in drying, though slightly fainter. When dried they closely resemble small forms of *L. camphorata*. Until I have made further collections I hesitate to describe this plant as a distinct species, but it seems to me to be more than a variable form of *L. camphorata*, and hence I shall assign it the rank of subspecies under the following name and characterization:

64*a*. **Lactaria camphorata fragilis** subsp. nov.

Pileus soon depressed in the center, with or without an umbo, very thin, snuff-brown (*30*3) or burnt-umber (*304*) toward the center, not fading, azonate, dry, glabrous, pruinose, sometimes rugose in the center 2.5–3.5 cm. broad, margin crenate and somewhat sulcate; gills maize-yellow (*36. t. 4*), not crowded, about five times broader than the thickness of the pileus; stem burnt-umber, stuffed, becoming hollow, 2–5 cm. long, 4–6 mm. thick; latex watery, mild, abundant. Other characters like those of *L. camphorata*.

The type specimens are in the herbarium of the N. Y. Bot. Garden and are *no. 33*, 1907.

65. LACTARIA RIMOSELLA Peck, Bull. N. Y. St. Mus. **105**: 37 1906. [As *Lactarius*]

Pileus fleshy, thin, rather firm, convex-umbonate, then depressed in the center, brownish-terra-cotta (*334*) fading to red-brown-terra-cotta (*332. t. 1*) azonate, dry, glabrous, rugose from the center, then cracking into minute areas, 3–6.5 cm. broad, margin involute then arched, even, sometimes wavy; gills whitish, then somewhat ochraceous, and finally colored like the pileus, a few forking near the stem, close, decurrent, 4–6 mm. broad; stem colored like the pileus, but not so expallent, equal or tapering upwards, pruinose at the apex, tomentose at the base, stuffed, then hollow, 2–6.5 cm. long, 5–10 mm. thick; flesh isabelline when young, colored like the pileus when old, odor faint, somewhat like that of *L. camphorata*; spores white, broadly elliptical, echinulate, $7 \times 8\,\mu$; latex watery or colored like skimmed milk, taste mild, but a little woody.

HAB.: In mixed woods under beech trees among ferns; also "on bare soil in woods or on banks of earth by roadsides" (Peck) July and August.

DISTRIB.: New York, *Peck* (type); Vermont, *Burlingham 39*, 1906.

ILLUST.: Bull. N. Y. St. Mus. **105**: *pl. 95. f. 7–11.*

DISTINGUISHING FIELD-MARKS: This species resembles *L. camphorata* in size and color, but differs in the pileus becoming rimulose-areolate, in its fading to a more pinkish-terra-cotta when mature, or in any case as soon as collected, and in the thin bluish-white or watery milk. The odor, which is very faint, does not become stronger in drying.

The type specimens are in the herbarium of the N. Y. State Museum at Albany.

66. LACTARIA SUBDULCIS (Pers.) Fr. Epicr. 345. 1838. [As *Lactarius*]

Agaricus lactifluus dulcis Bull. Herb. Fr. *pl. 224 A, B.* 1784.
Agaricus subdulcis Pers. Syn. Meth. Fung. 433, 434. 1801.
Lactarius subdulcis Fr. Epicr. 345. 1838.
Lactarius subscifluus Longyear, Rep. Mich. Acad. Sci. **1901**: 57 59. 1902.

Pileus fleshy, thin, firm, convex, papillate, becoming depressed to infundibuliform, fulvous (*308*), isabelline (*309*), or reddish-fulvous, not fading, azonate, dry, glabrous, smooth, 1.5–5 cm. broad, margin involute, then spreading, sometimes flexuous; gills whitish or tinted with isabelline, becoming pruinose, sometimes forking, close, adnate or decurrent by a tooth, up to 3 mm. broad; stem of the same color as the pileus or paler, nearly equal or tapering upwards, glabrous, or sometimes slightly pubescent at the base, dry, stuffed, becoming hollow, 2–7 cm. long, 2–6 mm. thick; flesh whitish or tinted with isabelline or fulvous, odor none; spores white, globular to broadly elliptical, echinulate, 7 × 8 μ; latex white, unchanging, mild or slowly acrid to bitterish. *Edible.*

HAB.: In the woods or on the border of woods, common. July to September.

DISTRIB.: New York, *Peck*, *Earle*; Vermont, *Jones*, *Burlingham 9*, 1906; Maine, *White*, *Murrill*; Connecticut, *Underwood*; New Jersey, *Ellis*, *Murrill & Earle*; Pennsylvania, *Murrill*; Virginia, *Murrill*; Alabama, *Underwood & Earle*; Illinois, *Glatfelter*; Ohio, *Beardslee*; Missouri, *Glatfelter*; North Carolina, *Burlingham.*

ILLUST.: Barla, Champ. Nice, *pl. 20. f. 4–10* (poor); Bern. Champ. Roch. *pl. 38. f. 1.* (bad); Bolt. Geschichte, *pl. 3*; Britz. Lact. *f. 31*; Bull. Herb. Fr. *pl. 224. f. A, B*; Cooke, Br. Fungi, *pl. 1002* (poor); Cordier, Champ. Fr. *pl. 26. f. 1* (very bad); Gillet, *pl. 171*, [*393*]; Hahn, Der Pilz-Sammler, *f. 13* (poor); Harzer, Pilze, *pl. 53* (very bad); Lanzi, Fung. Mang. *pl. 51. f. 3*; Quél. Champ. Jura, *pl. 11. f. 3* (bad); Roumeg. Crypt. Illust. *f. 141* (uncolored); Sicard, Hist. Nat. Champ. *pl. 44. f. 238*; Sowerby, Eng. Fungi, *pl. 204*, *Agaricus lactifluus* (?).

EXSIC.: Ellis & Everhart, Fungi Columbiani *1736*; Herpell, Sammlung präparirter Hutpilze *48*; Karsten, Fungi Fennici *510*; Thümen, Fungi Austriaci *913*; Sydow, Mycotheca Marchica *3320.*

DISTINGUISHING FIELD-MARKS: The fulvous or isabelline color of the pileus and stem, the rather thin but firm pileus, which is dry, glabrous, and usually smooth, the lack of odor when fresh or in drying and the mild then slightly bitterish-acrid taste of the white latex. The plants are comparatively small and slender.

There seems to be much variation in the color of the plants as well as in the form. I have found specimens which differed from the typical *L. subdulcis* only in having the margin distinctly striate,

or the surface rugose, and both of these I suspect to be common variations in the plant. Gillet describes three "varieties" of *L. subdulcis*, two of which Peck reports to have found in the United States, but I have collected only one of these, *rufa*. These two forms, which Gillet terms "varieties," he describes as follows:

Stem spongy, cap becomes more concave, of a deep live russet-chestnut, but unpolished, taste sweet. *rufa*.

Stem full, then hollow, cap russet-cinnamon, sublustrous, taste sweet, then acrid, bitter. *cinnamomea*.

Lactarius subseriflnus Longyear differs from the typical *L. subdulcis* only in the more distant gills and the crenate margin, and the watery latex. It seems to me to be a depauperate form of *L. subdulcis*, due probably to ecological conditions, all of the specimens having been collected in high, open woods. Mr. Longyear states that they were growing with small forms of *L. subdulcis*.

67. LACTARIA SERIFLUA (DC.) Fr. Epicr. 345. 1838. [As *Lactarius*.] —Schröt. in Cohn, Krypt.-Fl. Schles. 3: 534. 1889

Agaricus serifluus DC. Fl. Fr. 6: 45. 1815.

Agaricus gynaecogalus Otto, Versuch Agar. 75. 1816.

Pileus fleshy, firm, not very thick, at first plane with the margin inrolled, then depressed with the margin elevated, brown-fawn (*307*), azonate, dry, glabrous, 5–8 cm. broad, margin sometimes flexuous; gills yellowish, close, decurrent 2–3 mm. broad; stem of the same color as the pileus, nearly equal, dry, glabrous, solid, shorter than the breadth of the pileus, 4–7 mm. thick; flesh whitish; spores whitish, subglobular, echinulate, 7–8 μ; latex semi-transparent, resembling whey, mild (acrid, *fide* DC.), scanty.

HAB.: On ground in woods, in moist and shaded places. July and August.

DISTRIB.: New York (Long Island), *Peck*. It has also been reported from Pennsylvania by Herbst.

ILLUST.: Berkl. Outl. *pl. 13. f. 4*; Britz. Lact, *f. 37* (poor); Cooke, Br. Fungi, *pl. 1012*; Krombh. Abbild. *pl. 40. f. 15, 17, 18*; Lucand, Champ. Fr. *pl. 6* (good); Peck, Bull. N. Y. St. Mus. 105: *pl. 95. f. 7–11*.

EXSIC.: Sydow, Mycotheca Marchica *611*.

DISTINGUISHING FIELD-MARKS: The whey-colored, semi-trans-

parent latex is the prominent feature of this plant. In color it varies from brownish-fawn to cinnamon, or it may approach the color of *L. camphorata*. Peck says that our plant has a slight aromatic odor, but no mention of an odor is made by the European writers, and it may prove not to be constant in the American plant

68. LACTARIA ISABELLINA Burl. Bull. Torrey Club **34**: 88. 1907. [As *Lactarius*]

Pileus fleshy, not very thick, convex, then broadly convex, at length infundibuliform, umbonate, red-fulvous in the center, buff (*309*) toward the margin, all fading to buff when mature, azonate, dry, glabrous, somewhat roughened and wrinkled in the center

FIGURE 15. *Lactaria isabellina* Burl. *No. 38*, 1907.

especially when old, 3–4.5 cm. broad, margin glabrous, even or at length faintly striate, sometimes areolate-wrinkled; gills pale-yellowish, or tinted with the same color as the pileus, becoming reddish where bruised, forking near the stem or midway to the margin, close, thin, slightly decurrent, 3 mm. broad, or twice the thickness of the pileus; stem of the same color as the pileus, equal or slightly tapering upwards, tomentose at the base, stuffed, becoming hollow, 4 cm. long, 6 mm. thick; flesh white, staining yellowish from the milk; spores white, slightly echinulate, 6–7.5 μ × 7–8.5 μ; latex white, at length (after five minutes) becoming sulphur-yellow, or at least staining the gills and flesh yellow, astringent, then acrid, abundant. (FIGURE 15.)

HAB.: In leaf-mold or sphagnum, moist, mixed or spruce woods. August and September.

DISTRIB.: Vermont, 460 meters, *Burlingham 85*, 1906, type; North Carolina, 1500 meters, *Burlingham 38*, 1907.

DISTINGUISHING FIELD-MARKS: This species differs from *L. subdulcis*, which it most closely resembles, by the richer buff color and by the change in the color of the latex or bruised portions of the gills and flesh. The type specimens are in the herbarium of the N. Y. Botanical Garden.

69. LACTARIA MUTABILIS Peck, Ann. Rep. N. Y. St. Mus. **43**: 66. 1890. [As *Lactarius*]

Pileus fleshy, thin, convex, then nearly plane, reddish-brown, the disk and zones darker, zonate when moist, azonate when dry, moist but not viscid, glabrous, 5–10 cm. broad; gills whitish, becoming tinted with yellow in the mature plant, close, adnate, broader than the thickness of the pileus; stem of the same color as the pileus, equal or slightly tapering upwards, glabrous, stuffed, 2.5–5 cm. long, 6–10 mm. thick; flesh colored like the surface, odorless; spores subglobose, rough, 7.5 μ; latex white, unchanging, mild.

HAB.: "Low damp places." June and September.

DISTRIB.: New York, *Peck.*

ILLUST.: Peck, Ann. Rep. N. Y. St. Mus. **43**: *pl. 1. f. 1–4.*

DISTINGUISHING FIELD-MARKS: The large size, the reddish-brown color, and the zonate condition of the moist pileus. According to Peck, the zones are made up of "more or less confluent spots." The dried specimens resemble *L. subdulcis* in color, but they are much larger.

The type specimens are in the herbarium of the N. Y. State Museum at Albany. I have not seen this plant living and the above description is arranged from the original description after an examination of the type specimens.

70. LACTARIA PARVA Peck, Ann. Rep. N. Y. St. Mus. **29**: 44. 1878. [As *Lactarius.*]—Hennings, in Eng. & Prantl, Nat. Pflanzenfam. **1**^{1**}: 216. 1898

Pileus fleshy, thin, broadly convex or nearly plane, then slightly depressed in the center, sometimes with a small umbo, at first umber tinged with lilac, fading, azonate, dry, glabrous, 1.5–3 cm. broad, margin inrolled and pruinose at first, then spreading, even; gills whitish or yellowish, becoming pale dull-green where injured, and at length brownish, some forking near the stem, close, adnate to slightly decurrent, 2–4 mm. broad; stem paler than the pileus, equal or slightly tapering upwards, glabrous or merely

pruinose, stuffed, 1.5–5 cm. long, 4–10 mm. thick; flesh tinted with umber, staining pale dull-green, then brownish where injured, odorless; spores white, subglobose, slightly echinulate, 6.5–8 μ; latex white, unchanging, tardily but decidedly acrid.

HAB.: In woods on decaying wood. August and September.

DISTRIB.:, New York, *Peck* (type); Vermont, *Burlingham 101*, 1906.

The plant has been collected also by Guillet in Toronto, Canada.

DISTINGUISHING FIELD-MARKS: The pale dull-green color which the wounded gills slowly assume serves to separate this species from the other members of this group with the exception of *L. varia*. It may be distinguished from the latter by its smaller size, the prevailing umber color of the pileus and stem, and the perfectly glabrous, smooth surface of the pileus. For the most part *L. parva* grows on decaying wood in moist woods, while *L. varia* grows on the ground.

The type specimens are in the herbarium of the N. Y. State Museum at Albany.

71. LACTARIA VARIA Peck, Ann. Rep. N. Y. St. Mus. 38: 126. 1885. [As *Lactarius*.] — Hennings, in Eng. & Prantl, Nat. Pflanzenfam. 1[1**]: 216. 1898

Pileus fleshy, thin, convex, then plane, depressed in the center, sometimes with a small umbo, gray to brown, often with lilac tints, azonate, or rarely narrowly zonate on the margin, not viscid when moist, glabrous, sometimes minutely roughened by pits, which cause silvery reflections as though the pileus were micaceously atomate, 2.5–7.5 cm. broad; gills whitish to cream-colored, staining pale dull-greenish where wounded, close, adnate to decurrent; stem of the same color as the pileus or paler, equal, glabrous, stuffed, firm or spongy, 2.5–6 cm. long, 4–8 mm. thick; flesh white, odorless; spores white, 7–8 μ; latex white, unchanging, slowly acrid.

HAB.: On the ground in moist woods. September.

DISTRIB.: New York, *Peck* (type); Vermont, *Jones*; Massachusetts, *Davis*; New Jersey, *Sterling*.

DISTINGUISHING FIELD-MARKS: This species varies so much in color that that characteristic alone cannot serve to distinguish it, but the prevailing gray color together with the glabrous, dry,

sometimes glistening pileus, the change in the color of the wounded gills and the lack of odor will help to determine it. In color it often approaches *L. parva* Peck, but, judging from the specimens of the latter which I found in Vermont and the type specimens of *L. varia*, the two species are plainly distinct, although closely related. The type specimens of *L. varia* are a pale gray, while *L. parva* remains some shade of umber when dried. As I have not seen *L. varia* living, I have arranged the above description from the original description and some additional notes from Professor Peck and from observation of the type specimens which are in the herbarium of the New York State Museum at Albany.

DOUBTFUL SPECIES

LACTARIA ILLACHRYMANS Berk. & Rav. Berk. & Curt. Ann. and Mag. Nat. Hist. II. **12**: 425. 1853. [As *Lactarius*]

"Small; pileus thin, firm, convex to plane, then umbilicate, pale-fulvous, obscurely two- to three-zonate; stipe solid, white; lamellae white, crowded, narrow, subdecurrent, not milk-bearing when broken; taste slightly aromatic, subacrid."

HAB. and LOC.: In swamps in South Carolina, *Ravenel.*

This species has been reported also from North Carolina by Curtis. I have not seen the type specimens, but the coloration and zonation given in the above description would indicate that the species belongs to the *Lactariae*, and that the absence of milk may have been due to the age of the plant or to the fact that when the milk is scanty it will exude only immediately as a vigorous mushroom is collected. I would suspect that this number represented a form of some plant which is under favorable and normal conditions latex-bearing.

LACTARIA ALBIDA Peck, Rep. N. Y. St. Mus. **38**: 126. 1885. [As *Lactarius*]

"Pileus thin, plane or slightly depressed, glabrous, dry, white; lamellae subdistant, adnate or slightly decurrent, white, the interspaces venose; stem equal, solid, glabrous, white; spores white, .0003 to .00035 in.; milk white, taste acrid."

I have not seen this growing and the dried plant specimens do not show distinguishing characteristics. Professor Peck says in a recent letter, replying to an inquiry regarding this species, "Have

found in the Catskills a small form of what I take to be *L. albidus* Pk. The species belongs to the section *Russularia*, and I am not quite sure it is more than a white variety of *L. varius* Pk., which belongs to the *Russularia*." Further collections will undoubtedly serve to place this either as a distinct species or as a form of *Lactaria varia*.

DOUBTFUL SPECIES

Lactaria mitissima has been reported from Pennsylvania by Herbst and from California by Harkness & Moore, but the specimens from which the determinations were made have not been preserved. The description given by Herbst seems to conform very closely to *L. subdulcis*. The species is described in McIlvaine's One Thousand American Fungi, 181, and is figured in Cooke's British Fungi, *pl. 1001*. It may be distinguished from *L. subdulcis* by the more golden-fulvous color of the pileus and the orange stem, and by the more abundant latex. In Fries, Monogr. Hym. Suec. **2**: 180, the pileus is described as subviscid when moist. If this condition exists, the species should be classed with the *Quietae*.

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(Synonyms in Italics)

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OBSERVATIONS ON THE CALIFORNIA VINE DISEASE

BY

ORMOND BUTLER

ISSUED JUNE 18, 1910

Observations on the California vine disease

ORMOND BUTLER

(WITH PLATES 1–5)

I

Introduction

In the height of the summer of 1886, the grape-vines in Los Angeles and bordering counties, in California, began to show very marked and alarming symptoms of disease. The vineyards in the environs of Anaheim, then a flourishing viticultural center, were the most seriously affected. In fact, Anaheim is generally considered the birthplace of the scourge that had thus suddenly appeared and was, within the next few years, to devastate Los Angeles and Orange counties. The Anaheim disease, as the new malady was called before it received the name of California vine disease, gradually decreased in violence in each succeeding year after 1886, and, today, one may say that it is little feared by the growers. To be sure, Anaheim is no longer a viticultural center, but the vine is nevertheless extensively grown in places where the malady existed in 1886, and there are vineyards in Los Angeles County that have passed through the years of the epidemic without serious loss.

But if the California vine disease is a malady of little economic importance in 1910, it was a very grave problem to face in 1886. In August of that year F. W. Morse began an investigation of the malady, under the direction of the director of the Agricultural Experiment Station, University of California, and published, a few months later, the first description that we have of the California vine disease.

From this author we gather: that the disease first became apparent by a failure of the vines to bud, or, as occurred more generally, in a noticeable backwardness in starting, which often extended to six weeks, the foliage of the vines thus late in leafing

out soon becoming blighted; that the disease might affect the vine at any time from early spring until the autumn; that it was reputed to be, in some cases, very rapid in its action, affecting an apparently healthy vine in the space of a day. Morse himself had observed no such rapid changes, the changes noticed being only "such as one may frequently note in any vineyard where sudden variations in meteorological conditions occur, and sunburn or scald follows";[1] predominantly, however, the progression of the disease was gradual.

The malady was characterized, to continue our quotations, by a "drying up, and apparent burning of the foliage at all times, up to the time of ripening of the fruit. . . .[2] The leaves in general have the very decided appearance of sunburn. When the vineyard is seen as a whole the foliage looks withered, leaves partially dried and wrinkled, and large parts of them have become red, the affected part of each leaf assuming no regular shape or particular position. The canes having the most upright growth and those most exposed have the leaves the worst affected; low growth is less troubled."[3]

"Among the several varieties the Mission is, undoubtedly, the worst affected. . . . Other varieties such as Golden Chasselas, Sultana, Semillon and Sauvignon are affected to a greater or less extent, and in about the order named."[4]

Morse believed that the mortality of the vines was "due to more or less accidental and local peculiarities of climate, soil, moisture conditions, etc."[5]

In a report[6] submitted to the State Board of Viticultural Commissioners in 1890, Dowlen described the California vine disease with care, and added some remarks on the anatomy of the canes of affected vines which I shall have occasion to quote later. This

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[1] Morse, F. W. Report of an examination into the phenomena and causes of a supposed vine disease in Los Angeles County. Report of the viticultural work during the seasons 1885 and 1886, College of Agriculture, University of California, 176, 177. 1886.

[2] *Loc. cit.*, 176.

[3] *Loc. cit.*, 177.

[4] *Loc. cit.*, 178.

[5] *Loc. cit.*, 183, 184.

[6] Report California Viticultural Commissioners for 1889–90, 57 et seq.

author did not advance any opinion as to the nature of the disease.

Pierce's important memoir[1] on the California vine disease appeared in 1892 and contains many facts and figures of interest. In describing the disease he says: "In the majority of diseased vines, although not in all varieties, the leaf presents distinct characters. They may be mentioned as *constitutional* and *localized* characters."[2]

The general, or constitutional effects are "due to a failure in the formation of chlorophyll, or degeneration of that once properly formed, in those portions of the leaf supplied by the finer spiral vessels. These general effects are found to some extent in nearly all varieties. . . .

"*The localized effects upon the leaf* are most clearly seen in the white varieties, and are especially distinct in the Muscat." The leaves become more or less covered with yellow spots "in that part of the parenchyma supplied with the finer spiral vessels. These spots are often well defined, the outline being very sharp and distinct. . . ."[3]

"The cane usually becomes bare of leaves before the wood is properly ripened. The end of the cane, being last to ripen, is most immature, and soon after the leaves fall the unripened parts turn black and become dry. This progresses more rapidly and the dying is more complete when the leaves drop early. . . . The peculiar and unequal ripening of the cane is very marked."[4]

In the roots "among the first signs of disease is a discoloration and shrinkage in diameter of the finer root fibers, the root hairs and cap. This progresses until the tissue begins to decay. . . . The root, at last becoming wholly rotted, passes into a brown, loose, amorphous mass."[5]

The fruit of diseased vines is markedly affected. "If the first attack of the disease be violent the grape will sometimes fall from

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[1] Pierce, N. B. The California vine disease. U. S. Dept. Agr., Div. Veg. Path. Bull. 2. 1892.

[2] *Loc. cit.*, 41.

[3] *Loc. cit.*, 42.

[4] *Loc. cit.*, 46.

[5] *Loc. cit.*, 51 et seq.

the bunch. This dropping of the fruit is not so strongly marked and is less important than the drying of the berry upon the bunch. . . . In some cases the growth of the berry is retarded. . . . The drying of the fruit upon the vine is a leading effect of the disease and is very general in all varieties and under all conditions."[1]

Pierce states that the California vine disease has a period of incubation. He says "In the affected district it is common to find a vineyard of one variety looking perfectly healthy and the adjoining vineyard of another variety badly affected or killed by the disease. It may be that the vines are of the same age and upon like soil. When we see a sharp line of this kind," he continues, "drawn between varieties it is folly to say that the disease has affected one and not the other, for it may occur that the dying variety is found on all sides of the living one. It must be admitted, then, that the disease has produced its effect upon vines not yet showing those effects." Again, "it is also common to find a few Mission vines scattered here and there in vineyards of other varieties, they having been planted through oversight and the mixing of cuttings. Where this has been the case, these Mission vines have been singled out and killed by the disease as surely as if they were by themselves in adjoining vineyards. . . . The truth is, that all the vines have felt the same influence of the disease, but on account of difference in hardiness some show this influence earlier than others."[2] Another, and more striking feature of the malady is the overbearing of the vines "while the disease is incubating." But overbearing is not a constant symptom. Pierce notes the fact, and at the same time remarks: "That overproduction has not always been noticed is but negative evidence, and its well-attested occurrence in a reasonable number of cases is of more value than much negative evidence."[3]

The California vine disease appears also to be transmitted in cuttings.

Pierce does not come to any conclusion regarding the nature of the disease.

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[1] *Loc. cit.*, 53.

[2] *Loc. cit.*, 57.

[3] *Loc. cit.*, 58.

In 1892 Viala and Sauvageau also published a note on the California vine disease in the Comptes Rendus, and a memoir on the Brunissure and the California vine disease in the Journal de Botanique, which was republished later in the Annales de l'École Nationale d'Agriculture de Montpellier. These authors described the anatomical features of the California vine disease very accurately, as I shall have occasion to point out later, and concluded that this malady was produced by a myxomycete very similar to the organism causing Brunissure (*Plasmodiophora Vitis*), but as it was infinitely more destructive they gave it specific rank under the name *Plasmodiophora californica.*

In recent years Ravaz[1] has advanced the opinion that the California vine disease and the Brunissure are one and the same malady, both being due to overbearing, but the description I give of the latter disease in chapter III will show that this view is incorrect. If we modify, however, Ravaz's opinion to read that the Brunissure killed a number of the vines during the epidemic of 1886 in southern California, I think that it can then be supported on grounds. But I shall not attempt to advance the arguments in favor of this modification of Ravaz's view; it would lead me too far to do so adequately, and a brief presentation is, in the nature of the subject, impossible.

II

Description of the California vine disease

A. MORPHOLOGY

The California vine disease affects primarily the leaves, fruit, shoots, and canes. The arms and trunk reveal nothing of diagnostic value, and an examination of the roots is fruitful in contradictory results.

The leaves, fruit, shoots, and canes show symptoms that are constant from one variety, or species, of vine to another, the observable discrepancies being due to the fact that the virulence

[1] Ravaz, L. Influence de la surproduction sur la végétation de la vigne. Ann. École Agric. Montpellier, II. 6: 5–41. 1906.

Remarques sur le dépérissement de quelques vignes en Tunisie et en France. Progrès Agricole 44: 41–50, 71–73. 1905.

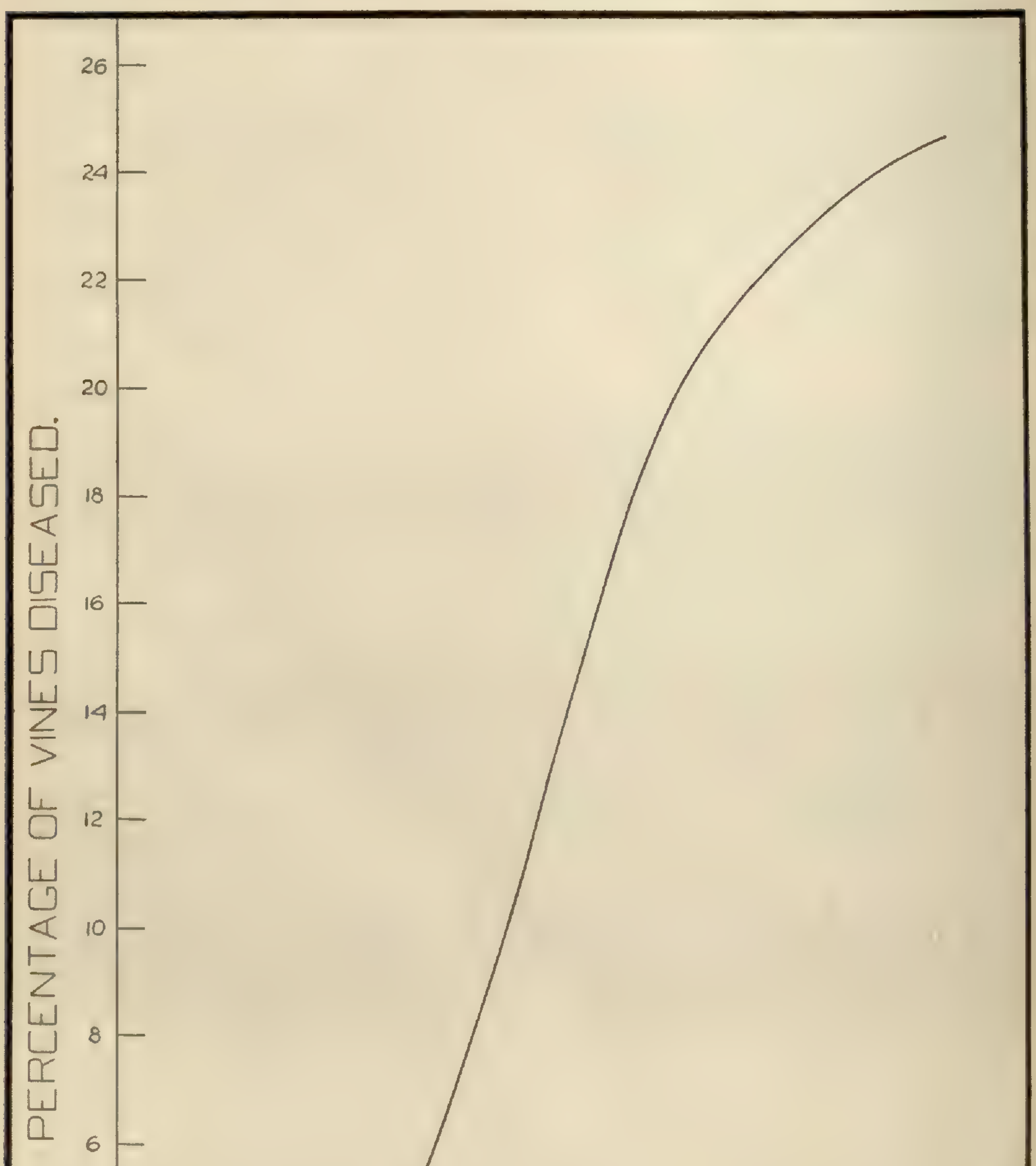

FIGURE 1.—Curve showing the general course of development of the California vine disease.

of the disease is subject to marked variations. These variations are both individual and inter-individual. The symptomatic differences between two plants are often found in replica on the shoots of a single vine. The disease, in fact, appears to work, to use a colloquialism, without rhyme or reason. It may affect a single shoot, or several shoots; one side only, or the whole of a vine. One vine may show all its characteristics, manifold though they be, and another, a part, perhaps only one, of them. The disease may never proceed beyond the first stages, a not uncommon feature, or it may develop slowly until all its characters are patent to the most casual observer; more often, however, its development is rapid.

The California vine disease, though it may appear at any time of the growing season, usually develops to a noticeable extent only when the vines are ripening their fruit, that is, at the most critical period of their yearly development. This fact is brought out very clearly in the accompanying graphic, which may be considered representative when 25 per cent. or more of the vines in a vineyard are diseased. When less than twenty-five vines in one hundred are affected, the curve may become either flatter or sharper: flatter, if the malady develops gradually throughout the growing season; sharper, if the disease develops very rapidly. As soon, however, as one quarter of the vines become diseased it tends to assume the form shown in the graphic.

The development of the disease is sporadic; and the malady always develops in the following general manner whether few or many vines are affected:

A certain number of scattering vines show the ominous symptoms; then more vines, unrelated positionally to the others, become affected, and thus, by the continued addition of diseased individuals, a vineyard becomes, to a greater or less extent, infested. There is no such thing, however, as spreading by contiguity, no "oil spots." Such a thing as a diseased center, using the term in its narrower sense, does not exist, nor is there in the different varieties of the grape-vine, if we confine ourselves to the Viniferae, any marked difference in predisposition. One cannot predict, as in the case of the powdery mildew, for instance,

that the disease will first appear in this or that variety. We only know that at *A* the disease may affect almost exclusively *x*; at *B* that *y* is worse than *x*; and at *C* that *y*, *u* and *v* are equally, or almost equally affected. But such observations as these are only good for the season in which they are made; they may not be true for the year before, nor yet in the year to come. In a word, the past is no criterion of the future: this is true whether the vines become diseased suddenly or progressively, and I mean by this latter term an intermittent addition rather than a natural sequence of symptoms.

I have said that the past is no criterion of the future. This statement, while true for the individual vine, is not necessarily true for the vineyard as a whole. When a large percentage of the vines in a vineyard are affected, not suddenly[1] but progressively, it is not infrequent that the disease reappears the following years and becomes chronic, as it were, in a large number of vines, though it is impossible to select with certainty the vines in which it will be so, and gradually, in bad cases, so weakens them that they die.

From the behavior of diseased vines, both as individuals and collectively, it appears that the California vine disease is sufficiently variable in its mode of action to be considered as possessed of two forms, differing from one another in immediate virulence. The one we may call apoplectic, from the suddenness of its action; the other chronic, from its lesser destructiveness and predisposition to recurrence. These two forms, identical symptomatically, conduce, the one rapidly, the other slowly, to the same end, the death of the vine. It is, therefore, unnecessary, in describing the disease, to state specifically which of these two forms one has in mind, the line of demarcation between them being, to all intents and purposes, but a line in point of time.

This being so, the following description determines the California vine disease, provided the characters of the affected organs are considered in conjunction with one another and not as separate and sufficient entities; for, and it cannot be too strongly urged, the disease we are considering cannot be surely and safely

[1] When a vine is affected suddenly in all its shoots it frequently dies of chlorosis the following season.

identified except in the "all together." Concretely: a vine showing but a *single* symptom of the California vine disease is, *in itself,* a doubtful subject.

Symptomatology

(*a*) LEAVES.—The young leaves—on upper third of shoots—generally show particular characters only in the case of the chronic form of the California vine disease. When a vine is affected apoplectically they either remain normal or assume the characters common to the older and adult leaves or, when the shoots are defoliated without death ensuing, form a healthy plume, as it were, at their tips. In the apoplectic form the young leaves are not indicative, but in the chronic form they are very often premonitory symptoms; the vine first showing them may become no further diseased, but it is practically certain that other vines in the vineyard, if they are all of one variety and age, will, and not only lightly, but severely. The characters shown by the young leaves are, in the case of the chronic form, then of considerable interest.

They are:

Case 1.—The leaves become pale in the intervenium, growth ceases at the periphery—sometimes also between the veins—and death ensues. The tissues not immediately affected, not having reached complete development, continue growing, the leaves becoming paler in color, more or less convex, and, according to the amount of dead tissue other than peripheral, variously distorted. (PLATE I, FIGURES 1, 2, 3, 4.)

Case 2.—The leaves, leaves more developed than those just described but of the same coloring, do not become convex as a whole, but only in one or both wings of the petiolary sinus. This distortion is accompanied by a sinking of the tissues between the venation, and subsequent death.

In older leaves the symptoms of the disease are variable and cannot be accounted for by their position in regard to other diseased leaves. Those leaves that are still in fairly active growth may show the characters common to the young leaves described in Case 2. In other cases, and coincident with the furrowing and death of the wings of the petiolary sinus, there appear, to a

greater or less extent, between the veins of the remainder of the leaf-blade, suffused yellow or red spots, which, when their centers die, have the appearance of reddish brown maculations surrounded with aureolae of red or yellow, as the case may be.[1] (PLATE 2, FIGURE 1.) If instead of, or coexisting with, the spotting of the leaf we have a reddening or yellowing of the intervenium, the dead tissue forms strips. Marginal discoloration and death may occur, as in the adult leaves, but is not so frequent.

In fully developed leaves the leaf-blade is not deformed. The tissue between the veins, and the margin, also, very largely, becomes yellow or red, the discolored areas dying in time, the dead tissue assuming a color which ranges from *feuille-morte* to gray, according as the death has been rapid or slow. Instead, however, of beginning as a general discoloration of the intervenium, the disease may first appear as suffused greenish yellow spots, which, enlarging and becoming more definite in outline, often merge together, forming large maculations and stripes. These maculations and stripes may die to the edge of the healthy tissue itself, but are more often surrounded by aureolae, which may be red, red and yellow, or yellow alone. (PLATE 1; PLATE 2.)

The leaves near the base of the shoots sometimes show a slight variation from the characters just described. As soon as the spots appear between the veins, enlarge, and form stripes, the remainder of the parenchyma becomes chlorotic. Death in the diseased areas proceeds slowly and, when accomplished, the dead parts being soft and crumbly, the leaf is beaten by the winds into deeply incised fragments which hang together around the petiole.

Diseased leaves—this remark is generally applicable—fall sooner or later with, or without, their petioles. The fall of the leaf prior to that of the petiole occurs, so far as I have been able to ascertain, only when the intervenium becomes diseased immediately around it. The death of the parenchyma then involves the death of the apex of the leaf-stalk, and the blade becomes severed from its support.

[1] In the varieties of the grape-vine producing white fruit, the aureolæ are always yellow; but in those bearing colored fruit they may be both yellow and red on the same leaf, the predominant color varying with the variety.

(*b*) FRUIT.—The fruit may be affected at any time from setting to maturation. If the fruit is affected just after setting the whole bunch withers and falls away; if attacked somewhat later, on passing the hand over a diseased bunch, the berries will come away often with, not infrequently without, their pedicels—they may even fall of themselves. As the fruit grows older it does not fall, but may shrivel or, if nearing maturation, ripen imperfectly. This shriveling and imperfect maturation of the fruit is a feature of the California vine disease. "The drying of the fruit upon the vine," says Pierce, "is a leading effect of the disease and is very general in all varieties and under all conditions."[1]

(*c*) SHOOTS.—The effect of the disease on the shoots depends on the amount and suddenness of the defoliation, which, itself, is a measure of the quality of the attack. If the vine is affected apoplectically, the life of the shoots, or of the canes, will be more endangered than if it be affected with the chronic form of the California vine disease. The season of the year at which the vines are affected is also a factor of some importance. Vines that have suffered even complete apical defoliation on one, or several, of their shoots in early summer, that is while they are still growing vigorously, may not have them visibly damaged. This is evidenced by the fact that such defoliated shoots continue to elongate, after a period of rest, and throw out axillary foliage.

In the height of summer, and at maturation, defoliation brought about by either form of the disease is more serious. The growth of the vines has then normally ceased and their recuperative powers are low. In July, and to some extent, also, in August, defoliation is followed by a progressive dying of the shoots, the amount of death in each shoot being, as it were, a register of its defoliation. When the disease affects the vines after lignification has set in, and during maturation, the fall of the foliage leaves the canes very imperfectly formed. The shoots, instead of maturing properly, remain, to a greater or less extent, green. One side of a shoot will be mature, the other not. Maturation may have proceeded normally at the base, and be

[1] *Loc. cit.*, 53.

very disordered further up. Or again, lignification may be imperfect only around a few nodes, the internodes showing apparently normal maturation, and conversely.

If one cuts a smooth cross-section of a shoot or cane that is bearing diseased foliage, or has been defoliated, he will notice that the wood is slightly discolored. The pith is best seen in longitudinal section; it will be found discolored more or less discontinuously, or turned completely brown, if the foliage has fallen.

(*d*) SPURS, ARMS, AND TRUNK.—Externally, the spurs, arms, and trunk have the same appearance in diseased as in healthy vines. This is no longer true when cross-sections are examined.

In the spurs the woody tissue of the previous year is discolored and, often, more especially near the edge, zoned with darker lines. In the arms the zones become less marked, and disappear before reaching the trunk. The discoloration of the wood is much more persistent, but hardly descends to the roots.

Besides the characters just mentioned, the arms and trunk may show alterations due to die-back from old wounds, decay, and various other injuries interfering with the circulation. The tissues surrounding these impediments are generally affected in such a manner that their differentiation from those that have become diseased through the action of the California vine disease is impossible. The characters found in the arms and trunk, in the case of the California vine disease, are, therefore, of but very little diagnostic value, and, I am inclined to think, hardly worth the pains one must be at to find them.

(*e*) ROOTS.—The roots do not present any characteristic alterations. They are either diseased, or not diseased, according to the situation in which the affected vines are growing and the presence, or absence, of root parasites, either animal or vegetable. If the affected vines are suffering also from the *Phylloxera Vastatrix*, *Adoxus Vitis* larvae, or nematode worms, the roots will appear damaged; they may be decomposed by root-rot (*Dematophora Necatrix*), or dry-rot, simply die, or, a frequent occurrence, be entirely sound.

B. HISTOLOGY

TECHNIQUE.—In studying the anatomy of the California vine disease I have employed the usual cytological methods. The diseased tissues were prepared and placed, with rare exceptions, in the fixing fluid directly in the field.

The fixative that gave me the best results is one per cent. chromic acid. Flemming's solution does not appear superior to chromic acid as a fixative, and labors under the disadvantage of blackening the tissues to such an extent that details are masked, and decoloration of the sections in hydrogen peroxide has to be resorted to to bring them out. Even then, however, the chromic acid material gives preparations superior in sharpness and contrast. Sections made from alcoholic material give stained preparations that compare favorably with those obtained from chromic acid material. Though alcohol is not so good a fixative as chromic acid, I believe that it may nevertheless be advantageously substituted for it in many cases. The matter occluding the cell lumen in diseased tissues contains tannin, and is more or less darkened by the latter fixative, which is quite a disadvantage in all but very thin sections.

After fixing, the tissues were washed, passed into alcohol and through bergamot oil into paraffin; or, if working partly in the cold, from alcohol to chloroform, in which the paraffin was dissolved to saturation. Finally the chloroform was evaporated off at 60 degrees Centigrade.

The stain that gave me the best results for general purposes is acid fuchsin, a concentrated aqueous solution of bichromate of potash being used as the differentiator.[1] This stain, prepared by dissolving 20 grams of acid fuchsin in 100 cubic centimeters of aniline water, gave me the best results when used in the following manner:

The sections to be stained, previously fixed to the slide, were covered with warm acid fuchsin, which was kept steaming hot, but not boiling, for a few minutes. The sections were then washed and plunged into warm bichromate, washed again in water, and mounted.

[1] Cf. Zimmermann, Botanical Microtechnique, 197. 1893. [Humphrey trans.]

The various other stains or reagents that I have used were prepared for the most part after the formulae given in Zimmermann's Botanical Microtechnique.

LEAVES.—From the description I have given of the appearance of diseased foliage it will be seen, upon close examination, that leaves have always one or another characteristic in common, and may be classified in two groups: first, those leaves in which the maculations and striations occur in a field of green; and secondly, those leaves in which the spots and stripes occur in a field of yellow. The young leaves that betray a diseased state only by the convexity of their blade and a pale color naturally belong to the second group, chlorosis being the characteristic of it.

This separation of the diseased leaves into two groups, while of little value for descriptive purposes, and I made no use of it, is of considerable assistance in their microscopic examination. I found, as would be supposed, that corresponding to the observed macroscopic differences, there existed microscopic differences. These latter differences, though less pronounced perhaps than the former, and more of degree than of kind, appear to best advantage and in their truer value when considered separately from one another. I have, therefore, considered in (*a*) the anatomy of those leaves possessing diseased areas and healthy areas; and in (*b*) the anatomy of those leaves that are entirely pathognomonic.

(*a*) If one cuts a cross-section through a leaf, being careful to include tissue in various stages of disease, it will present, under the microscope, very nearly the following appearance:

The epidermal cells (of upper surface and lower surface also, but to a markedly less degree in the latter) are full of matter in the diseased areas which becomes less dense and gradually disappears as one enters the healthier tissues. This matter may be globoidal, homogeneous, or coarsely or finely granular. (PLATE 3, FIGURE 4; PLATE 4, FIGURES 3, 4, 5.) The globoidal form is infrequent, homogeneity the rule; and both forms do not go beyond the areas of marked disease. When the globoidal form is present it may pass over into the homogeneous, or disappear as the healthy tissue is approached. The homogeneous deposit,

however, invariably changes in density, and not infrequently in character, on nearing the healthy tissues.

In the palisade cells the deposit, as a rule, corresponds in density with that in the abutting epidermal cells (when there is a difference it will be in favor of the latter), but extends greatly beyond the outer limit of the matter in these cells. Homogeneity of the deposit is the rule, though it occurs now and then in granular form, the size of the granules varying from cell to cell, but not to any extent in the individual cell. The incrusting of the primordial utricle of the palisade cells is a striking and constant feature. The density of the incrustation decreases, as one passes from diseased to apparently healthy tissue. (PLATE 3, FIGURES 4, 6; PLATE 4, FIGURE 4.)

In the lacunose tissue the incrusting of the lumen is not so regular or so marked as in the case of the palisade layer. The row of lacunose cells adjoining the palisade tissue is more free from it than the others, though there is no absolute constancy in this matter. These cells contain not infrequently, though scatteringly, a few globules much smaller and constitutionally different from those in the epidermal cells, as will be shown subsequently. In the remaining cells of the lacunose tissue the deposit is either homogeneous or granular, dense or thin, corresponding, in this respect, with the variations in the palisade layer. (PLATE 3, FIGURE 4; PLATE 4, FIGURES 3, 4, 5.)

The chloroplasts are sometimes absent from the older portion of the diseased areas; when present their degeneration is marked, but, I should add, not unexceptionally, as sometimes palisade cells may be found filled with dense homogeneous matter in which chloroplasts, still containing starch, lie embedded. Degeneration, however, is the rule, but is more noticeable and has progressed further wherever the deposit in the cells is less dense; the chloroplasts may then be observed as protean plasmodium-like masses, sometimes of considerable size, from aggregation of individuals. As one progresses towards the healthier tissues, and with the decrease in density of the deposit, the chloroplasts are generally more difficult to observe, their resorption having usually progressed further. (PLATE 3, FIGURES 3, 4, 6; PLATE 4, FIGURES 3, 5.)

The degeneration of the chloroplasts, like the incrusting of the primordial utricle, proceeds further in the palisade than in the lacunose tissue. In the cells of the lacunose tissue the chloroplasts do not, as a rule, form large plasmodium-like aggregates. They become vacuolate, but usually without distending to any extent, and, in the row of cells next the palisade layer, when the lumen is free, are inclined to fragment or degenerate into oil-like bodies. (PLATE 3, FIGURES 3, 4; PLATE 4, FIGURES 3, 5.)

The vessels of the minor bundles of the leaves are occluded more or less by granular or homogeneous matter, and the same may be said of the bast, cortical parenchyma, collenchyma, and epidermis of the main veins. (PLATE 3, FIGURE 5.)

Thylloses are often present in the vessels of the main vein. (PLATE 4, FIGURE 1.)

Viala and Sauvageau, in their study of the California vine disease, remark that a "section cut through an apparently uniformly diseased area often shows breaches of continuity due to healthy starch-replete cells which may be coextensive with the diseased tissue."[1] This observation, while perfectly correct, applies only to diseased leaves taken from varieties of grape-vines bearing black grapes. In these varieties diseased centers may be surrounded directly by red aureolae,[2] and the cells in this reddened tissue are replete with starch. When therefore, the aureolae of diseased centers are contiguous, or we have an intervenar stripe dying irregularly, the prenecrotic color being red, such an irregular alternation of starch-replete and starch-free cells may occur. The presence of starch, however, is pathognomonic, and not indicative of health, as the authors just quoted believed. When, as occasionally happens, the dead tissue abuts directly on that which is still green, without apparently any intervening morbid cells, we do not find such a thing as starch-replete and starch-free cells. In fact, in section, what appeared macroscopically as a decided line of demarcation is certainly

[1] Viala, P., & Sauvageau, C. La Brunissure et la Maladie de Californie. Ann. École Agr. Montpellier, 7: 101. 1892. [Translation.]

[2] The reddening of vine leaves, so far as I have observed, is always accompanied by a starch congestion. See Ravaz, L., & Roos, L. Le Rougeot de la vigne. Progrès Agricole 44: 363–370, 392–398. 1905.

not distinctly delineated; disorganization of the cell constituents proceeds into the green tisue and starch, if present, is nowise abundant.

(*b*) Examined in cross-section, those leaves in which the appearance of the disease is followed by a progressive chlorosis of the entire parenchyma differ from those in which it remains normal, *i. e.*, *Case a.*, rather in degree of occlusion of the cells and degeneration of their chloroplasts than otherwise.

The deposit in the epidermal cells (upper epidermis almost exclusively) is either homogeneous or granular, apparently rarely globoidal. It is never very dense, though generally homogeneous in character where the tissue is longest diseased, and becomes granular and finally disappears as one proceeds into the surrounding chlorotic tissues.

The deposit in the palisade cells is usually homogeneous and thin, or more or less granular, and proceeds well into the healthier tissues. Starch is rarely to be found. The chloroplasts are largely resorbed—those still remaining being smaller than in normal tissue and reticulate—in the surrounding chlorotic tissues, and, in the diseased spot itself, form only comparatively small plasmodium-like aggregates. (PLATE 4, FIGURE 5.)

In the lacunose tissue the cells abutting the palisade layer are the freest from deposit; they are frequently almost empty. The remaining cells do not differ much in appearance from the palisade cells; their lumen, however, is freer from deposit.

The deposit in the cells of the lacunose tissue is either homogeneous or granular.

Occlusion of the vessels of the smaller veins is not general, nor do thylloses appear to occur in the vessels of the main veins.

I have just described the general microscopic appearance of sections cut through diseased leaf tissue. I will now describe in detail the anatomy of the pathognomonic tissues with the view of determining as far as possible the nature of the catabolic processes brought about in them.

In describing the California vine disease I said that this malady may appear spontaneously as it were, or develop more or less slowly. This statement applies not only to the individual vine but to individual leaves.

We found that the leaf dies in spots or stripes, infrequently without prenecrotic coloration, the rule being a reddening or yellowing before death, even though all the stages are concurrent as it were; we found that exceptionally the disease appears as yellow maculations, isolated or running together, when death is slow and confined to the diseased areas, even though the leaf turns chlorotic—but I did not lay particular stress upon the point that when death is very rapid, the dead tissue has a somewhat glossy brick tint, that when less rapid it is more reddish brown and matte and when slow, fawn-colored. These differences in coloration of the dead tissue have, however, considerable anatomical importance.

If one examines sections through material showing the color characters mentioned above, he will obtain a conspectus of the behavior of the chloroplasts. Thin sections must be cut, owing to the opacity of the deposit in the lumen of the cells, when the chloroplasts may be well brought out by acid fuchsin,—carbol fuchsin and iron haematoxylin (the first gives the clearer preparations) do not give as sharp a differentiation. Acid fuchsin might almost be called a specific chloroplastid stain. Sections placed in it for a few minutes, and then washed in bichromate, will show the chloroplasts deep red, the cytoplasm very faint rose, the other cell inclusions being practically colorless. By means of this stain the chloroplasts may be studied without fear of misinterpretation. Carbol fuchsin and iron haematoxylin, the latter especially, did not appear to me quite so trustworthy and were soon discarded.

If we take, then, a series of sections through diseased tissues that have died with various rapidities and stain them, preferably in acid fuchsin, we shall find that the resorption, vacuolation and plasmodium-like aggregation of the chloroplastids is, to a certain extent, inversely proportional to the amount of lumen occlusion. In the tissues that have died very rapidly the deposit is homogeneous, dense, and the chloroplasts hardly show more than a slight vacuolation and some appear, in optical section, as hollow elliptical spheres; their center is not a vacuole, however, but a starch grain, as the blue color they assume on the

addition of an iodine solution readily shows. (PLATE 3, FIGURE 4.) This observation regarding the presence of starch in a few chloroplasts applies only to those cases where the prenecrotic coloring of the diseased tissues is red, but does not apply when the change of hue is not apparent or yellowish. In these cases the chloroplasts do not appear to contain starch, and their vacuolation is more pronounced, which fact would lead one to suspect that death does not really occur without some previous discoloration of the tissues, however transient it may be.

When the death of the tissues is less rapid, vacuolation and distension of the chloroplasts is marked, and one will observe plasmodium-like aggregates here and there in the cells, but in more important masses at the lower extremities. With the final occlusion of the lumen all further changes are arrested. (PLATE 3, FIGURES 3, 6; PLATE 4, FIGURES 3, 4, 5.)

When the cells die with moderate rapidity, *i. e.*, when the sections are taken from typical diseased leaves, the vacuolation and plasmodium-like aggregation of the chloroplasts seems to reach a maximum. The homogeneous matter occluding the lumen, though still dense, is light-colored.

As the rapidity of death still decreases, the tendency of the chloroplasts to run together is less marked; though still vacuolate, they distend less and their resorption progresses further and further. The density of the deposit in the cells also decreases. (PLATE 4, FIGURE 5.)

Finally we come to the stage (diseased leaves that become entirely chlorotic, the original diseased areas dying first and thus remaining distinct) when sections through an autumn leaf near its fall and a diseased leaf differ not at at all or very little in appearance; traces of chloroplasts may remain in both cases, and the lumen may also be slightly occluded by homogeneous or granular matter. (PLATE 3, FIGURE 2; PLATE 4, FIGURE 5.)

The chloroplasts up to the stage of plasmodium-like aggregation stain readily, but as their resorption progresses further, they stain less readily and, in fact, at the final stage (autumn-leaf stage may I not call it?), they hold the acid fuchsin less readily—the other cell inclusions not at all—and decolorization in potassium bichromate is unnecessary.

The facts that I have just related in regard to the behavior of the chloroplasts refer almost exclusively to the cells of the palisade tissue. In the cells of the lacunose tissue the chloroplasts become vacuolate, but remain small, as a rule, and their resorption progresses gradually. The occluding of the lumen of these cells does not occur so rapidly and is rarely so dense or dark in color, even in the most rapid cases of death, as that of the palisade cells.

I remarked, in a previous passage, that the row of cells of the lacunose tissue abutting on the palisade layer was very free, when compared to the other cells of the same tissue, from deposit. When the lumen of these cells is free from deposit the chloroplasts not only become vacuolate but fragment and, it would appear, decompose with the formation of oil-like bodies, which, when small, stain like the chloroplasts, but do not color, when larger, as vividly, if at all, in acid fuchsin, which fact leads me to believe that, if originally largely decomposing chloroplastid remnants, they grow by accretion of other proteid substances; this is brought out clearly when sections are stained with rosaniline: the smaller bodies will appear red, the others violet. They all stain, however, more vividly in safranin and eosin than the chloroplasts themselves, which would tend to show that their composition is fairly complex.

During the course of my remarks on the behavior of the chloroplasts I have frequently made mention of the homogeneous substance filling the cell lumen. The various stages of chloroplast degeneration we found to depend on the relative amount and rapidity of production of this substance. It is therefore, important for us to determine the nature and origin of the homogeneous deposit and its homologues, the globules and granular matter. This I will now attempt to do.

From my observations on the degeneration of the chloroplasts it plainly appears that the substance occluding the cell lumen is not a product of their decomposition. That from the decomposition of the chloroplasts there appears to result, in some cases, the formation of oil-like bodies is no contradiction to this statement. The latter form of decomposition is rare. Furthermore, the fact

that the decomposition of the chloroplasts is in inverse ratio to the density of the occluding matter, precludes the assumption that, in the major cases, these bodies act as nuclei of condensation, like crystals in supersaturated solutions. But if the chloroplasts play no part in the formation of the homogeneous matter, or its homologues, whence does it come? The answer to this question involves considerable difficulties, and must, at best, be largely hypothetical.

The deposits in the lumen of the cells are probably genetically related, though it would appear, from their variation in form, that their ultimate composition is somewhat different. They all behave very similarly to reagents and stains. They dissolve in Javelle water, but are not at all, or but little, affected by either hydrochloric or sulphuric acid. A concentrated solution of potash has practically no effect on the homogeneous and granular matters, but will sometimes remove the globules in the epidermis. Fixing diseased tissues in Flemming's solution is apt to make the homogeneous, granular, and globoidal matters so dark that, for staining purposes, sections taken from such material are very imperfect. Chromic acid, one per cent. solution, does not change the color of the cell occlusions to any extent, and sections taken from material fixed in it are hardly more opaque than those taken from alcoholic material.

The deposits in the cells turn black when the sections are placed in a saturated solution of iron acetate; the black color Flemming's solution imparts to them may be very largely removed by peroxide of hydrogen.

Amongst the stains, iron haematoxylin[1] is retained vigorously by the deposits, but Böhmer's haematoxylin is without effect. The homogeneous matter colors deep red in safranin, takes eosin readily, colors in erythrosin, tropaeoline OO, carmalum, rosaniline[2] (dull red), orcein and hydrochloric acid.

From these reactions of the deposits it is clear that they contain tannin (action of iron acetate, regeneration of osmic acid by

[1] I mordanted the sections in "liquor ferri sulfurici oxidati," diluted with two volumes of water, for twenty-four hours; stained in 1 per cent. solution of hæmatoxylin (Benda's) and differentiated in 20 per cent. acetic acid.

[2] An alcoholic solution of equal parts fuchsin and methyl violet.

hydrogen peroxide), proteid matter (eosin, safranin); that they contain also a gum, somewhat similar to wound-gum, would appear from their reaction to orcein and rosaniline.

The deposits in the cells are, then, complex in composition, but it is not improbable that a decomposition product of starch forms their predominant ingredient. The following facts strengthen this view:

The cell walls and cytoplasm of healthy tissues stain blue in Böhmer's haematoxylin, but pathognomonic tissues, on the other hand, do not. If Böhmer's haematoxylin and safranin are used together the healthy tissues will appear as we have just described them, but the cell walls and cytoplasm, when diseased, are red or reddish. This would prove that a decided change takes place in the cell walls of diseased tissues simultaneously with the change in the cytoplasm, but as this change is visible only upon coloration, it is not likely that the cell walls contribute materially to the formation of the deposits in the lumen. The deposits must, therefore, arise as decomposition products from one or more of the cell contents. I believe that starch is the most important contributing substance of them all, and circumstantial evidence favorable to this view is not lacking.

We have seen that the more rapid the death of the leaf the denser the occluding deposit. We have seen also that when the tissues die suddenly without apparent prenecrotic coloration, they are, nevertheless, as free from starch as tissues that become previously colored. We have seen also that reddened tissues are replete with starch and practically free from deposit, but no sooner die than occlusion becomes noticeable and starch, to all intents and purposes, absent; we have seen further that the longer the period of chlorosis before death, the freer the cell lumen from deposit, and starch, it is well known, is quite scarce in chlorotic tissues. It appears to me, therefore, that the substance (of the nature of wound-gum) found in the cell lumen, as granular or homogeneous matter, is largely derived from starch.

The deposits we find in diseased cells do not appear to contain pectic substances in any considerable amount, for Victoria blue and chloriodide of zinc do not give the typical reactions, and the

retention of methylene blue seems to be due to the presence of tannin.

In my observations, just described, on the anatomy of diseased leaves, I never mentioned that hyphae, plasmodia, and bacteria were always absent from pathognomonic tissues: such, however, is the case. In diseased tissues that have not been weathering under conditions favorable to the growth of fungi or bacteria no foreign organism of any kind is to be found. I must, therefore, deny the existence of *Plasmodiophora californica*, but in so doing I wish to impugn only the interpretation of Viala and Sauvageau, not the correctness of their observations. The facts exist as they saw them, but not as they interpreted them.

CANES.—The anatomy of the shoots of diseased vines does not reveal any facts of importance until they begin to mature. Their maturation is somewhat fantastic and the resulting canes appear interspersed with green immature tissue. This immature tissue constitutes the immature spots so characteristic of the California vine disease and will, therefore, occupy our attention almost exclusively in the following remarks.

I think it well, for clearness sake, to preface my observations on the immature spot with a brief description of a healthy cane, as seen in cross-section. We find, around the pith, a ring of wood composed of wood-fibers and large vessels interspersed radially, at equal intervals, by the ligneous medulla; beyond the wood, the cortex, corresponding to the wood fascicles, the basts containing two to three or four rows of fibrous bundles and separated by a parenchymatous and widening prolongation of the medulla; beyond the bast, and separating it from the remaining cortical tissues, the suber; beyond the suber, and capping the basts, as it were, the pericycles; the other tissues, parenchyma, collenchyma, and epidermis, have turned brown, and have more or less collapsed.

In immature spots the departure from the normal, as I have sketched it, is as striking as unexpected. Around the pith we find the ring of wood to be of unequal, instead of equal, diameter, and the wood fascicles to be of unequal development: at the center, or to one side of the center, in the immature spot, they

are very undersized and the vessels themselves fewer in number and subnormal; the phloems corresponding to these undersized wood fascicles are greatly reduced in size, free from bast-fiber bundles, which normally should be 2 or 3 in number, and covered with dwarfed pericycles. As one works towards the sides of the immature spots the wood fascicles increase in size and assume normal proportions; the phloem correspondingly increases in size, but the production of the bast fibers is slow, and at first fragmentary; the pericycles are soon of a size with those in matured tissue. There is no production of suber in the typical immature spot; it ends abruptly at the immediate edge of the matured tissues. With the production of the suber, if the cane is perfect, except for the immature spot, the bast fibers are produced normally. Starch is present in the matured tissues, but not in normal amount, if at all, in the immature spot.

If we now examine in greater detail the modifications occurring in diseased canes, we will find that the above description applies only to those canes in which the immature spot occurs solely on shoots which are not only apparently but also morphologically matured. These canes are, however, rather the exception than the rule, and we find more frequently immaturity and morphologically imperfect maturity forming, to macroscopic vision, immature spots and maturity respectively. Furthermore, if one examines a sufficient number of canes, he will find that the immature spot is not morphologically constant: it may resemble more closely a morphologically matured cane than the cane, macroscopically speaking, on which it is found. I think it best, therefore, seeing the confusion that is liable to arise in the mind of the reader, to precede all further remarks by three comprehensive definitions: he will then know exactly what I mean when I speak of an immature spot; and my dual use of the term cane will not be ambiguous.

Cane (morphologically perfect).—Tissues exterior to the endodermis brown, dead; suber strongly developed; phloem normally developed; bast fibers never absent.

Cane (morphologically imperfect).—Tissues exterior to the endodermis brown, dead; suber well developed; phloem perfectly

and imperfectly developed; bast fibers absent more or less over extended spots.

Immature spot.—Any part of the cane (perfect or imperfect) in which the cortical tissues, from epidermis to endodermis, still preserve all the characters of live tissue.

With these definitions in mind, the reader will be better able to appreciate the extent of the morphological changes that occur, and I do not pretend to cite them all, in diseased canes.

Immature spot.—(*a*) No suber is laid down in the immature spot; it stops on one side beneath the pericycle, then jumps above it and runs out to the epidermis. The phloem, at this point, contains but one bast fiber bundle; the second phloem (immature spot), contains but an imperfectly developed one, and the third (one half the normal size), none. Where the immature spot begins on the other side we have the following state of things: the suber ends beneath the pericycle, but has attempted to push through one end; there is then a break and an attempt to form suber above the next pericycle. The phloem beneath the pericycle under which the suber stops contains two rows of bast fiber bundles, but five phloems further on they have completely disappeared, and the bast itself is about one half its normal size. (PLATE 5, FIGURE 1.)

(*b*) The suber stops, as a definite layer, at the edge of the pericycle, but may continue for a while as a feeble thread. We find the following striking anomaly in some cases: the suber, upon arriving at the immature spot, jumps above the pericycle, and the cortical parenchyma, for a certain distance, intermittently even, divides in an attempt at suberization. The cell walls of the phloem are generally discolored, in some cases markedly so, especially where abnormal suberization of cortical parenchyma has occurred. Bast fibers are present; three or more bundles may be observed in each phloem, generally two, sometimes only one. The bast fiber bundles are always imperfectly developed, even when three in number. The following condition is sometimes met with: one phloem will contain three bundles of bast fibers, the next none and the next two, or the conditions shown in PLATE 5, FIGURE 3 may be observed.

(*c*) The suber is always produced. The normal number of bast

fiber bundles seems to be produced and the phloem is of normal size.

(*d*) The production of suber is scant, and occurs at about the position normally occupied by the second bast fiber bundle. The phloem is much reduced in size, and the bast fiber bundles are obsolete.

(*e*) The suber is continuous: it has not always formed immediately below the pericycle, but frequently several rows of phloem cells beneath it.

(*f*) The suber is continuous in the immature spot and lies well within the phloem. The bast fiber bundles, which are normally developed at the edge of spot, gradually dwindle down to a fragment of one, and disappear. Following the decrease in the number of the bast fiber bundles there occurs a parallel decrease in the size of the phloem; when the bundles disappear the phloem is about one half its normal size. (PLATE 5, FIGURE 2.)

Cane.—The canes on which the immature spots I have just described occurred were all morphologically imperfect. Morphologically mature tissue would interchange, by gradations, with morphologically immature tissue, and the immature spots would form a break in one or the other, or, as it were, the connecting link between the two. Where the formation of the tissues was the least perfect the wood fascicles and their corresponding phloems were much undersized, and no bast fiber bundles were formed.

I have just shown that in diseased canes the morphological variations are considerable, and the reader will naturally expect, as a consequence, considerable variation in the cell pathognomonics. These variations, though in themselves interesting, are not sufficiently important to warrant particular mention, and I shall, therefore, confine my attention to a general description, taking for type a section through a cane in which the cells show considerable disease. The part of the cane most diseased will be, as a rule, the immature spot.

Dowlen says, in describing the histology of diseased canes, that in "those canes which have one side ripe and the other side unripe, the tissues of the ripened portion are almost always well supplied with starch—some starch will always be found—whilst

in the unripened portions the tissues will be altogether devoid of starch. In the discolored areas of the woody bundles, the components of the tissues are seen either to have their walls simply stained brown or else the cell cavity is partially or wholly filled up with a black brown deposit. . . . The larger ducts and vessels are often seen to be more or less filled up with thylles, which are developed sometimes to a great extent."[1]

These observations are correct. Canes taken from diseased vines show a paucity of starch, and, when treated with 1 per cent. iodine solution, give (macroscopically) no starch reaction at all. In section taken through canes with immature spots, starch will usually be found under the microscope, generally in the matured tissues, though, contrary to Dowlen's observations, I have found it in the immature spots, and in larger quantity when suber is produced than when it is not. Its entire absence, however, I have also observed. The presence or absence of starch in the cortex depends, I believe, on the production or nonproduction of the suber. The presence of starch in the xylem, ligneous medulla and pith near the protoxylem depends also, to a certain extent, on the production or nonproduction of the cork—the relation, however, is not so apparent.

The presence, or absence, of starch also bears a very close relation to the quantity of brown granuloid, globoidal, or homogeneous matter found in the diseased cells. The production of these homogeneous substances is proportional to the amount of starch present. The freer the cells from occluding matters, the freer the sections from starch.

In a cross-section of an immature spot one will observe, suber being present, the following condition of affairs:

The pith cells encircling the protoxylem are full of starch or of starch and brown, more or less finely divided matter, which may become coarser, predominant, or even run together into a pseudo-homogeneous mass and entirely fill the cell lumen, the starch grains being perceptible only here and there as clear spots. In other cases the brown masses are more globoidal, or fill the space between the starch grains like a cement, or encom-

[1] Dowlen, E. Report of Board of State Viticultural Commissioners for 1889–90, 60. 1890.

pass the starch in a brown translucent film. Where the medullary rays begin, and in the secondary wood, this occluding matter is darker; the starch grains are blackened, or appear to lie in a blackish matrix, or the lumen of the cells may be filled with a homogeneous black mass. Sometimes before the medullary rays reach the cortex the following change takes place: the starch has largely disappeared from the cells, and the brown irregular lining of their walls appears to be due to an incrusting of the primordial utricle. In the cortex the medullary rays present the following appearance: the lumen of the cells is more or less filled with yellowish or brown homogeneous matter. The deposits are darker where the bast fibers have not been produced. Brown homogeneous matter occludes the greater number of the phloem cells. The cells in the cortical parenchyma, collenchyma, and epidermis may also be more or less occluded. Thylloses are generally present in the primary wood, and are not infrequently very numerous in the secondary wood; they contain now and then granuloids. The discoloration of the cell walls in the different tissues is, except, perhaps, in the neighborhood of the cambial layer, rather inconstant.

Outside the immature spot the occlusion of the cells is less pronounced, though of the same general character.

The matter occluding the cells in the diseased canes does not appear to differ, for the most part, from that filling the cells of the leaves. Microchemically, the gummous substance in the cells of the mesophyl does not differ from the occluding matter found in the cells of diseased canes. This statement, though generally true, needs to be qualified: the reactions characteristic of the deposits found in the leaf are more constant in the cortex, and especially in the phloem, than in the wood, in this latter tissue a great deal of browning of the primordial utricle seems to be due to death rather than to particular catabolic changes—hence the normal appearance of the starch.

Roots.—The roots may be either healthy or show, without structural modification, to a lesser or greater degree, the same character of cell occlusion I described as occurring in the cells of diseased canes, less the accompanying starch when decay is evident.

The homogeneous form of the deposits may still persist in roots in the last stages of decay. Pierce observed in very decomposed roots corroded homogeneous matter. He says: "a microscopical examination of the decaying outer parts of the vascular bundles shows that the cell lumen is filled with a translucent amber-like deposit. This persists after the decay of the cell wall, and presents rod-shaped, more or less irregular and eaten, amber-like casts."[1]

To sum up our microscopic observations in a few words: An examination of the various organs of a diseased vine—leaves, canes, fruit, roots—fails to reveal the presence of any parasitic organism. In all organs exhibiting signs of disease we find, however, a polymorphous gummous substance, containing proteid and tannic matters, that appears to be derived from starch. In the leaves chloroplastid degeneration precedes the occlusion of the cell lumen, or is arrested by it.

III

The relationships of the California vine disease

I said before entering on the description of the California vine disease that the symptoms shown by the various aërial organs had to be considered in conjunction with one another, and not singly, if this malady was to be identified with any certainty. Such a statement as this implies that the symptoms of the disease are also more or less common to other maladies; and this upon examination we find to be the case.

A comprehensive study reveals the interesting fact that the California vine disease has features in common with the diseases known as Folletage, Rougeot, Sun-scald, Brunissure, Shelling, and Tetranychosis. What their common characteristics are I shall now attempt to show, and this will be best accomplished by short descriptions of the related maladies.

Folletage.—This disease may affect a vine either in part or in its entirety, is very rapid in its action, and, as a rule, fatal. Foëx tells us that all the vines in a vineyard are sometimes

[1] Pierce, N. B. *Loc. cit.*, 53.

affected.[1] Chauzit remarks that he has seen "vineyards in which one quarter of the vines were destroyed,"[2] and Professor F. T. Bioletti tells me that it has been known to destroy three quarters of a vineyard. The symptoms of Folletage vary somewhat with the rapidity of the attack; if the vines are affected and killed within the space of a day, the leaves fade, curl, and dry; but when the attack is less severe the seared leaves will be confined more to the apex of the shoots, the lower leaves being "much discolored, either with red or yellow spots or stripes."[3] The shoots always die from the apex downward and the fruit withers and dries up more or less according to the degree of its maturity and the seriousness of the affection on the shoots upon which it is borne.

The anatomy of Folletage does not appear to differ greatly from that of Brunissure.

Folletage generally occurs only at midsummer, but may affect vines as early as May.

The accredited cause of the malady is a rupture of equilibrium between absorption and transpiration.

Rougeot[4] is a mild form of Folletage and Pierce says the following description would apply to leaves of vines affected by this malady:

"The leaves of the dark varieties of grapes show a red discoloration between the veins and at the margin. In the earlier stages this color is faint, but later on the tissue lying between the main veins becomes bright red, and still later dies and changes to dull brown. The death of the leaf usually begins at the margin, or in the center of the red stripes lying between the veins, or it may involve both regions at once. The venation of the leaf remains green in most instances, forming a symmetrical green vein system after nearly all the intervening tissue is dead, or has turned red or brown. Thus there are in these later stages three distinct gradations of color in the affected leaves: (1) A brown and more or less dried margin, or bands of brown lying between the main veins, or both; (2) a band of bright red bordering the dead brown portion of the leaf; (3) normal green

[1] Foëx, G. Cours complet de viticulture, 573. [ed. 4].
[2] Chauzit, B. Revue de Viticulture **26**: 50. 1906.
[3] Pierce, N. B. *Loc. cit.*, 195.
[4] Rougeot of authors *pro parte*.

tissues outlining the main venation of the leaf. All colors vary according to the time since the first alteration took place. The petiole is not involved at once in any evident change, but later the leaf is cut off. A second variety of grape had leaves altered in a somewhat similar manner to those of the dark varieties described, but the bright colors did not prevail. There was little to be seen of a third color on these leaves. The alteration is almost directly from the normal green to a dull muddy brown, as if the base colors were yellow and black. The dead tissue occurs first at the margin, and in spots and stripes between the main veins, rarely if ever touching a large vein. Between this dead tissue and the green next the veins is sometimes a slight transitional shade of yellow, which is nearly wanting in many cases, the brown being directly joined to the green on either side of the main veins. Where the intermediate yellow line is wanting, the appearance of the leaf is very striking, and differs in color from any diseased varieties noticed in California. The pattern of the markings is, however, the same. The difference observable is a varietal one. The leaves of a variety of white grape were altered in the manner described for the Muscat of Alexandria in California. In the early stages the changes of the leaf are foreshadowed in faint yellowish spots in the parenchyma, which become more pronounced as the trouble advances. At this time the leaf may have a yellow speckled appearance. The spots are yet somewhat cloud-like and illy defined, and are rarely located upon a vein. As the discoloration becomes more marked these cloud-like spots are better defined at their margin and more and more of the parenchyma of the leaf between the veins becomes involved. As the light yellow spots enlarge the parenchyma at their center turns reddish brown and dies. Later there is a brown central stripe between the veins and at the margin of the leaf, and bordering this dead tissue is a line of half-dead yellow tissue lying next the green bordering the veins. All these markings are very distinct and well defined in the later stages of the trouble. As the death of the tissue between the veins progresses it gives to the green bands at the veins the symmetrical appearance seen on the Muscat leaf in California."[1]

Rougeot has been ascribed to the same cause as Folletage.

Sun-scald.—This malady is described as follows by Viala:

"Sun-scald appears as irregular intervenar, somewhat depressed *feuille-morte* maculations. Leaves are sometimes affected periph-

[1] Pierce, N. B. *Loc. cit.*, 186.

erally: in these cases the discoloration gradually works inwardly towards the petiole, the dead parenchyma assuming a dirty yellow or light brown color; in other leaves again the diseased tissues form sinuate intervenar bands extending from the petiole to the edge of the blade. The hairs of tomentose varieties are dry on those portions of the lower surface of the leaves that correspond to the diseased spots of the upper; they are white, agglomerated and bear a sufficiently close resemblance to the tufts of powdery mildew to have sometimes been taken for them. In some instances the leaves show small, more or less brownish spots. . . ."[1]

In severe cases Sun-scald gradates into Folletage.

Brunissure.—"The disease first appears on the upper surface of the leaves in the form of very small, very numerous yellowish brown spots, in the case of the varieties of the vine bearing white fruit, and as brown almost black punctuations, in the case of those varieties bearing colored fruit. As these spots are all very near one another, for they are separated only by the ultimate ramifications of the fibro-vascular bundles, they run together almost from the day of their inception. After coalescence has taken place they form yellowish brown or dark brown areas that cover the leaf-blades to a greater or less extent. Some cover only the space of half an inch, while others cover a quarter, one-third, the half, and sometimes even the whole of the leaf.

"These maculations appear indifferently here and there upon the blade of the leaf, now between the veins, now upon the tissues adjacent to the veins, and across the latter; now along the edges of the leaf, now at the center of the blade. In general they form between the veinlets, encroaching upon the main veins and the circumjacent tissues later."[2]

All the leaves do not become diseased at once. The basal leaves are the first to become affected, and the apical leaves, even when the shoots have ceased growing, are the last to become diseased; they may even, in mild cases, remain entirely healthy.

Brunissure has been studied by Viala and Sauvageau, Debray, Prunet, Ducomet, and Ravaz.

Viala describes the appearance of diseased cells as follows:

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[1] Viala, P. Les maladies de la vigne, 470 *et seq.* 1893 [ed. 3]. [Translation.]

[2] Ravaz, L. La Brunissure de la vigne. Ann. École Nat. Agric. Montpellier II. 3: 175 *et seq.* 1904. [Translation.]

"In the first stages of the disease the parasite develops more especially in the palisade tissue; it invades the cells of the lacunose tissue later, but is found only exceptionally in the epidermal cells. One observes in sections taken through recently affected tissue that healthy cells may contain starch in goodly amount, but that in the cells that are being invaded, it is much less abundant. The starch completely disappears with the spread of the parasite throughout the cell. . . .

"Wherever the leaf blade is brown the tissues are infested, only a few cells at most remaining healthy within the diseased areas. In sections taken through tissue but slightly affected one may find that the cells of the palisade tissue are uniformly affected and those of the lacunose tissue still healthy; in the worst affected tissues, however, the infection is general; all the cells of the mesophyl are filled with the plasmodium.

"The plasmodium varies considerably in appearance. In some cases it destroys the cell contents and entirely fills the lumen; when this is the case it appears fairly dense, is non-transparent and very granular; when observed under a high power the granular structure becomes vacuolate; one might say that the plasmodium presents the appearance of a sponge. At other times it lines the cell walls to a greater or less extent; this parietal plasmodium is more or less finely vacuolate and may be compared to fine lace-work. Protoplasmic strands sometimes join the various parts of the plasmodium and may even anastomose in a more or less complete manner.

"Finally, in a number of cases, especially in tissues in an advanced stage of disease, the plasmodium breaks up into more or less spherical masses, infinite in number and size; they are sometimes so abundant that the cells are choked with them. Among these spheroids we find some that are absolutely homogeneous, refringent, and oil-like; others that contain a large central or more or less excentric vacuole; lastly, others that are finely vacuolate and apparently composed of spongoid protoplasmic matter."[1]

What is the cause of Brunissure? Viala and Sauvageau believed that the vacuolate matter was a plasmodium, *Plasmodiophora Vitis*, and the globoids, homogeneous and granular matters, products of decomposition. Debray considered that the globoids and the homogeneous (cereous) matter as well and the vacuolate, plasmodium-like masses were one and all phases in the development of an organism, *Pseudocommis Vitis*. Prunet as a result

[1] Viala, P. *Loc. cit.*, 403 *et seq.* [Translation.]

of his investigations determined that Brunissure was caused by a fungus which he referred to the genus *Cladochytrium* Nowakowski. Ducomet, on the other hand, concluded that the vacuolate, plasmodium-like bodies were degenerate chloroplasts, and the globoids, granular and homogeneous matters, products of decomposition, and his results were confirmed later by Ravaz. Both Ducomet and Ravaz claimed that Brunissure was a physiological disease; they did not agree, however, as to its cause. Ducomet believed that the disease was induced by rapid changes of temperature, a sudden rise or fall of the thermometer being causal. Ravaz argued that the malady was due to over-production, and, in support of his thesis gave a great deal of data; he further strengthened his opinion by asserting that he could produce Brunissure at will.

Shelling.—In this disease "the leaves at the outer extremities of the shoots first show a yellow discoloration which follows more or less continuously the outer margin. . . ."[1] This "yellow portion dies and turns brown," and the leaf, as a consequence, curls at the edges. In older leaves and young leaves in which foliar development is exceedingly slow the following characters will be observed: "Small irregular blotches of a dark color appear between the veins, these enlarge rapidly, . . . and coalesce to fill up the space between the veins which remain green or yellow. These changes occur so rapidly that the foliage seems to change color suddenly. The contrast between the green or light yellow veins and dark purplish brown of the intervening tissues gives a peculiar streaked appearance to the leaves. In the most serious cases they curl up, become dry and brittle, and finally drop from the vine, leaving it nearly bare."[2] The most striking feature of the disease is, however, the fall of the berries from the pedicels.[3]

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[1] Lodeman, E. G. Some grape troubles of Western New York. Cornell Univ. Agric. Exp. Sta. Bull. 76: 416. 1894.

[2] Fairchild, D. G. Diseases of the grape in Western New York. Jour. Myc. 6: 96. 1891.

[3] It may be well to remark that though this feature of the disease is very striking, too much stress should not be laid upon it. The spontaneous separation of the berries from their pedicels and their separation only under the stress of a slight mechanical force are differences of degree, not of kind. *Americo* × *American direct producers* are subject as a class to shelling at

"As the season of ripening approaches, certain berries of the affected clusters fall to the ground on account of the inability of the main fibers and other connecting tissue of the fruit-stems to sustain their weight. . . . The portions of the clusters first affected are, so far as my observations go, invariably either the lower extremity of the cluster as it hangs from the cane, or, in the case of heavily shouldered clusters, the outer extremity of the stem forming the shoulder. . . . Sometimes only one or two berries may fall, but in other cases the drying and shriveling of the stem gradually extends upwards, the affected portion being plainly marked by the absence of the berries. . . . It often occurs that not a berry remains hanging upon the bunch. . . . Some clusters upon a vine seem to be more free from shelling than others upon the same plant."[1]

The development of shelling is sporadic. The disease affects vines at the height of summer and is as selective as Folletage or Rougeot. One, several, or all the shoots may be affected.

"It very commonly occurs that plants in certain portions of a vineyard shell, while the large majority of them do not. The line is sometimes so sharply drawn," our authority continues, "that the affected plant may be entirely surrounded by healthy vines; and it is not uncommon to find a healthy vine in the midst of those which shell. . . . Some clusters upon a vine seem to be more free from shelling than others upon the same plant. This seems to be due, in many cases, to its location upon the cane, but there are so many exceptions that no definite rule can be laid down. . . . Another peculiarity which may sometimes be seen, although cases of it are very rare, is the shelling of the berries upon only one portion of the vine, as for instance those borne upon the canes which spring from an arm, the difficulty thus affecting only one half of the plant. One case was noticed in which the clusters found upon one cane were the only ones which suffered, amongst all those borne by the vine."[2]

The cause of Shelling is not definitely known, though the weight of the evidence points to defective nutrition.

Tetranychosis.[3]—Young vigorously growing leaves become convex and paler than normal; they may even become somewhat

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maturity and the Viniferae are not entirely free from the trouble. Certain *Franco* × *Americans* behave similarly.

[1] Lodeman, E. G. *Loc. cit.*, 413–415.

[2] Lodeman, E. G. *Loc. cit.*, 415.

[3] Maladie rouge.

spotted with dead tissue and dry up peripherally. Leaves that have ceased rapid growth or are already fully developed become yellowish green and more or less covered with maculations between the veins. The spots spread over the intervenium, not so much from individual development as from increase of centers. The centers of the maculations die, but a running together of the dead areas to form stripes does not seem to precede the death of the whole surrounding parenchyma. As a rule the leaves die from the edges inwards, and in severe cases maturation of the shoots is interfered with; the canes appear spotted or striped with immature tissue. The anatomy of pathognomonic leaves may be briefly described as follows:

A deposit, in the epidermal cells of the upper surface and, to a less extent, of the lower surface, occurs in the most diseased areas only. It is homogeneous to all intents and purposes, and rapidly thins out in the healthier cells. In the palisade tissue, where the cells have not collapsed, they are either full of a homogeneous deposit or with granular matter. The chloroplasts are small, vacuolate, and scarce. The cells of the lacunose tissue in the row next the palisade layer, a certain number of them at least, contain disintegrated chloroplasts, but rarely globuloids. The remaining cells contain disintegrated chloroplasts as well as granular or homogeneous matter. The vessels of the small fibro-vascular bundles are occluded, more or less, with granular or homogeneous matter. The microchemical reactions of the deposits are the same as in the case of the California vine disease.

The disease is caused by *Tetranychus Vitis*[1] and may be held in check by sulphur or the polysulphides.

We may conclude from the study of the relationships of the California vine disease that this malady, while having many points of resemblance with other diseases, is, in diagnosing specimens, likely to be confounded only with Folletage, Tetranychosis or Sun-scald. I have just shown that all these diseases have at least one salient character that differentiates them from the California vine disease, and these characters are clearly

[1] Mr. N. Banks, to whom I sent specimens for identification, could not be positive, from the material at hand, whether this *Tetranychus* was *T. Vitis* or a variety of *T. telarius*, but was of the opinion that it was *T. Vitis* Boisduval.

observed on sufficiently fresh material that includes both the apical and basal portions of the shoots.

IV

Nature of the California vine disease

When empiricists agree, their opinion may be taken as having some foundation in fact. The grape-growers of California have always considered the California vine disease as a "top disease," and the facts undoubtedly support this opinion.

Nearly every observer who has written upon the California vine disease has dwelt at length upon the foliar characteristics of this malady, and either stated implicitly or expressly that it travels downwards, not upwards. Morse observes that "scattering vines which appear not to have made good growth last year, are dried up and dead to the roots, which in nearly all cases still contain sap."[1] Dowlen is of the opinion that the disease travels downwards. "The disease always travels downwards," he says, "both in vines and cuttings." "Some cuttings were purposely planted in an inverted position, still the result was the same; the disease always started at the end which was naturally farthest from the main stem, whether that end was placed in the air or in the soil."[2] That the disease does not affect the roots is an opinion that has been largely held by viticulturists, if we may judge from a letter published in the Pacific Rural Press of October 20, 1888.[3] "The published accounts of the disease which I have seen," writes Scribner, "assert that the roots are perfectly sound." But this is not exactly his opinion, for in the very next sentence we find him saying—"In every case examined by Professor Viala and myself we found the ultimate rootlets dead often for a foot or more from their tips." Scribner does not state, however, whether the vines examined were in the first or last stages of the disease, but I am inclined to believe, from the

[1] Morse, F. W. Report of the viticultural work during the seasons 1885 and 1886. College of Agriculture, University of California, 177. 1886.

[2] Dowlen. Report of Board of State Viticultural Commissioners for 1889–90. 1890.

[3] Letter of F. L. Scribner to Benj. Pratt, of Orange, Cal.

observations of Pierce, that they were in the latter, or, at least, in an advanced stage; for this writer says: "The time when the roots become diseased is difficult to ascertain, and will probably not be known before the nature of the malady is determined. . . . At present I incline to the opinion that the extremes of the vine show the early signs of disease at nearly the same time."[1] Viala and Sauvageau observe that "the disease gradually descends towards the base of the shoots, becomes manifest in the arms, the trunk, and later reaches the roots."[2]

My personal observations are in perfect accord with those of the authorities just cited. I have observed that the roots of diseased vines are not affected at the inception of the disease and will take the longer to show signs of weakness the healthier the vine, and the greater the amount of foliage still remaining in normal function. It is evident that when a vine is affected in all its shoots with a severe apoplectic attack, disorders in the finer roots will immediately take place; the sudden die-back of the shoots almost to the spurs will be followed by corresponding death in the rootlets—but if we take a vine that is diseased only in a few of its shoots, then its roots will not be different in appearance from those of the neighboring healthy vines. Visible symptoms of disease in the roots do not precede the appearance of disease in the shoots. When the roots decay it is because they are in a weakened state and external conditions are superinducive; this is evidenced by the fact that roots will dry-rot in one soil and soft-rot in another.

The visible seat of the disease being in the foliage, then, as popular opinion vouchsafes, and our own and other investigators' observations substantiate, it will be in the study of the behavior of the diseased vines and of the anatomy of pathognomonic tissues that we will find the answer to the question: What is the nature of the California vine disease?

I shall attempt to answer this question.

In the preceding chapter I established that the California vine disease does not differ in method of attack or propagation from Folletage, and showed also that the foliar characteristics of the

[1] *Loc. cit.*, 51.

[2] *Loc. cit.*, 99.

two diseases are in a large measure similar. The importance of this similarity is enhanced when the anatomical study of pathognomonic tissues in the former malady fails to reveal the presence of any foreign organisms, but simply shows a chloroplastid degeneration inversely proportional to the rapidity of death, and an occluding of the cell lumen by a gummous product probably due to starch decomposition. When we also consider that Roze is credited by Debray[1] with having found *Pseudocommis Vitis* (Syn. *Plasmodiophora Vitis*) in leaves taken from vines attacked by Folletage it can hardly be denied that the two diseases are very closely related, for this supposed organism is the cause of Brunissure, which malady I have shown to be undifferentiable anatomically from the California vine disease. Furthermore, we know that sun-scald may gradate into Folletage and, a fact also of capital importance, that this malady is prevalent in southern California—the home of the California vine disease.

The California vine disease, Folletage, Sun-scald, and Brunissure are then very closely related. In fact, a close and comprehensive study of the anatomical features of these diseases cannot help but lead one to the conclusion that all four are due to the some functional state in the vines themselves, outwardly indicated, owing to the play of external agencies, by somewhat different symptoms. This common functional state I shall call a lowering of functional activity; and for the following reason: In the California vine disease—one might say without grave inaccuracy in all four diseases—the anatomical changes observed follow very closely those occurring in autumn leaves, preeminently is this the case when the sequence of changes is slow. Now it is well known that the changes brought about in the leaves of deciduous plants in autumn are due to a lowering of functional activity. The rest these plants require after a certain period of growth takes place normally at the end of such a period, provided conditions are not conducive to its prolongation, without the determinant intervention of external agencies. The rôle of external agencies is largely of secondary importance; they hasten or retard autumnal changes in the leaves, but they will not bring them

[1] Debray, A. Bull. Soc. Bot. France 45: 256. 1898.

about unless the plant has reached the proper stage of development. But once the plants have reached the required stage in their development then external agencies may hasten or retard autumnal changes in the foliage. In countries with a cold winter climate it is a matter of common knowledge that the weather influences very largely the brilliancy of autumn tints, their period of duration and time of development, but is not, I repeat once more, the determinant factor: the plant must first have reached a certain stage of functional activity.

The changes occurring in the autumn leaves of vines, vacuolation and absorption of chloroplasts with, in cases, a slight production of globoidal and homogeneous matters—are similar to those observed in the California vine disease; one might say that they represent a diseased area of a leaf affected by the latter malady in a very mild form. If, therefore, in certain of its forms the California vine disease becomes microscopically identical with an autumn leaf it necessarily follows that Brunissure, Folletage, and Sun-scald are also related to it. In autumn leaves, then, and in the above maladies the same cause must be paramountly active. And as the changes observed in autumn leaves are due to a decrease in functional activity, the disease we are considering, *i. e.*, the California vine disease, may be said to be due to the same cause. But the same functional inactivity need not necessarily be operative in all cases:

In autumn leaves the changes are due to a decrease of vegetative activity; in the case of Brunissure, to overbearing, as appears from the researches of Ravaz; in the case of Folletage, Sun-scald, and the California vine disease, to a rupture of equilibrium between absorption and transpiration operating upon vines weak in their power of absorbing and translocating water, and brought about by external agencies favoring transpiration.

That it is really to a weakened state of the vine that the characteristics of the disease above mentioned are due, may be deduced from the conditions favoring their development. To consider, however, only the California vine disease, these conditions taken individually could not be held responsible for its development, but when considered as factors favoring the visual

manifestation of an organic weakness, they are worthy of consideration.

The California vine disease develops with greater intensity in sunshine than in shade, in wind-blown vineyards to windward rather than to leeward, and soil fertility and texture are not without influence. I shall examine more at length these factors, and independently of one another, though in reality, they cooperate more or less.

Shade.—The effect of shade on the development of the disease is marked. Pierce notes that vines well shaded are but slowly killed; that "shade has a marked retarding influence upon the work of the disease."[1] My own observations confirm this view. Vines shaded at the time the rupture of equilibium between transpiration and absorption is brought about in the open vineyard, whether by sudden insolation or insolation plus humidity or wind, are not affected except in extreme cases.

Insolation.—The effect of excessive insolation has been observed by Morse, who remarks that "many successive vines could be found with dead spurs of last year upon the sunny side, and not infrequently a line of dead wood extended with the fiber to or near the surface of the ground. No shoots started from this side. Suckering, if it occurred at all, came invariably from the north side, where the greenest wood was always found; in fact, I saw no line of dead wood upon this side."[2]

The deleterious effect of intense sunshine following a deposition of moisture is well known to all horticulturists. Morse thinks that water of condensation is not without effect in the burning of the foliage in some cases of the California vine disease. He writes: Those vines "which are protected more or less by trees, present a scalded appearance; some leaves show three different stages: about the margin, and extending an inch or so outward, they will be perfectly red and dead; next comes a zone of light green color, followed by another only slightly lighter colored than the healthy part of the leaf. These are usually most exposed to the sun. In the early morning large drops of moisture, almost equal to that from a heavy rain, are

[1] *Loc. cit.*, 111.

[2] *Loc. cit.*, 177.

found upon these vines, and it is probable that the hot sun scalds the leaves before the water is evaporated."

"It is quite noticeable that leaves exactly similar to those found injured in the open vineyard may also be found among the scalded ones."[1]

Wind.—The effect of wind on the development of the disease I have been able to follow closely. I have observed that the disease appears under the following climatic conditions: When hot, still mornings are followed by stiff breezes, the disease may be expected to appear, and if one walks through a vineyard that has become affected from this cause, with his eye to the wind, he will observe less disease than if he walk before the wind. The vines are affected to windward, which would be expected were transpiration difficulties the cause of the disease.

Soil texture and fertility.—Pierce observes that the rapidity with which vines succumb to the California vine disease depends upon the physical condition of the soil. Dividing the soils of the state into (1) "Heavy soils, including the red and black adobe and clay soils; (2) the gravelly soils; (3) the fine loose soils, including the sandy loams and the sands and fine sedimentary deposits of the river bottoms,"[2] he finds that "If conditions of age and variety are the same, the power of any vine to resist disease is about as follows upon the three classes of soils: (1) Least resistance upon coarse gravelly soils; (2) medium resistance upon soils of a heavy and compact nature; (3) greatest resistance upon level soils which are loose and sandy but not infertile."[3]

The rôle of soil texture on the development of the California vine disease I have been able to follow particularly well in one instance. In a vineyard already old and subject to the daily blast of the trade wind, I found that the disease first appeared where the soil was heaviest, developing later where an admixture of sand and fine gravel made it more open and penetrable, and this despite the fact that the free moisture was approximately the same in both cases.

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[1] Morse, F. W. *Loc. cit.*, 177.

[2] *Loc. cit.*, 96.

[3] *Loc. cit.*, 98.

CONCLUSION.—The facts gathered during the course of this paper point to the conclusion that the California vine disease is due to some weakness in the functions of absorption and translocation of water becoming manifest when conditions favoring transpiration are marked. To say that the disease is due to a rupture of equilibrium between absorption and transpiration does not conflict with any recorded observations. This is true whether one considers the disease from the point of view of the effect of external agencies upon its general development, or from the point of view of its development upon individual vines, or from the point of view of its symptomatology, anatomy, and relationships.

CORNELL UNIVERSITY,
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Explanation of plates 1-5

PLATE 1

1, 2, 3, 4. Young diseased leaves of *Vitis vinifera*, var. Mission.

5. Leaf of *V. vinifera*, var. Muscat of Alexandria, showing intervenar striations and death of tissues at edge of blade.

PLATE 2

Leaves showing various stages of disease.

1, 2, 3. *V. vinifera*, var. Mission.

4, 5. *V. vinifera*, var. Berger.

PLATE 3

1, 2, 3, 4, 6. Sections through palisade tissue of leaves in various stages of disease.

5. Cross-section of a small fibro-vascular bundle.

PLATE 4

1. Cross-section of part of a fibro-vascular bundle of a main vein showing development of thylloses in the vessels.

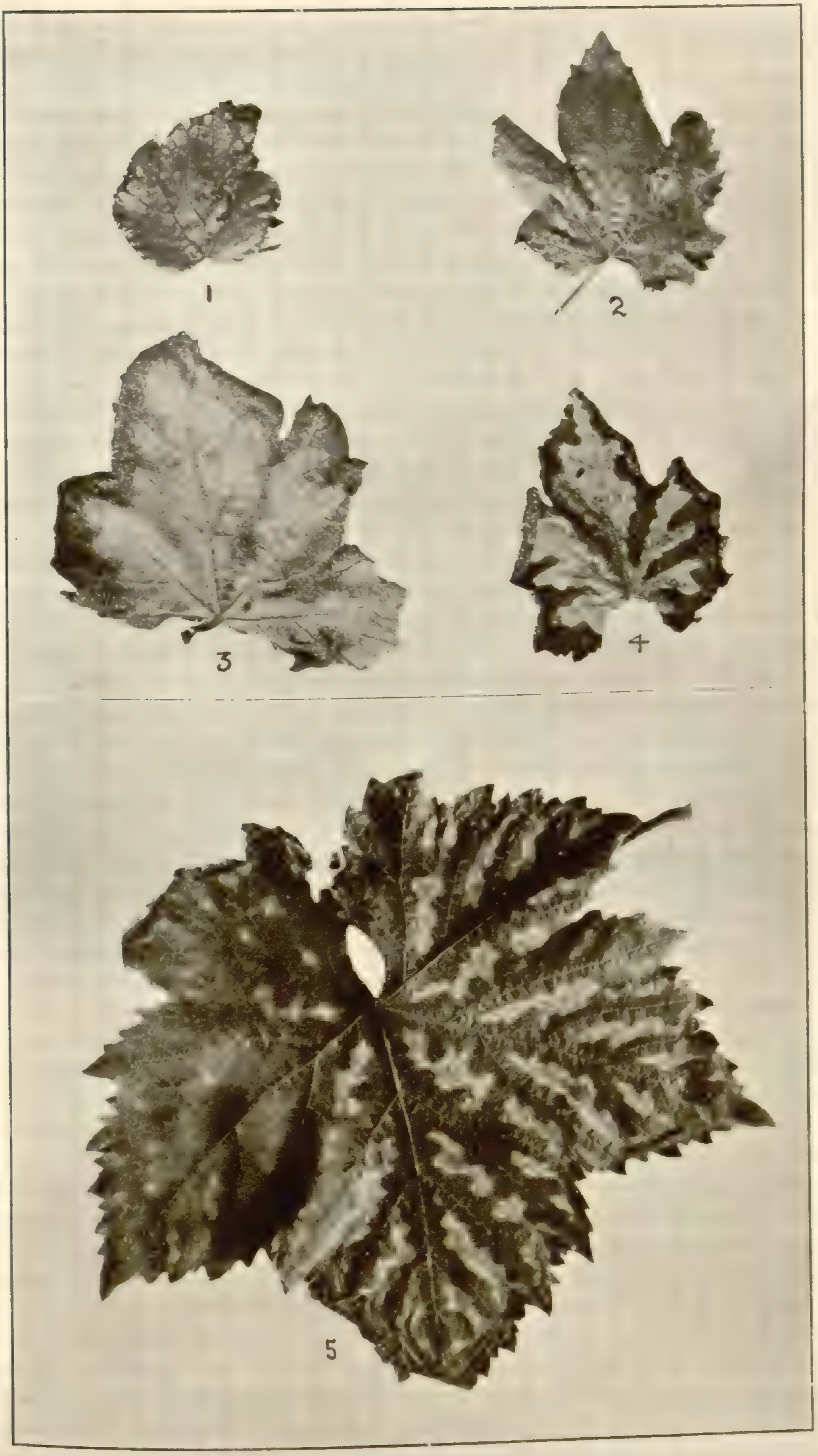
2. Section of healthy leaf showing normal appearance of chloroplastids.

3, 4, 5. Sections through palisade tissue showing various stages of disease.

PLATE 5

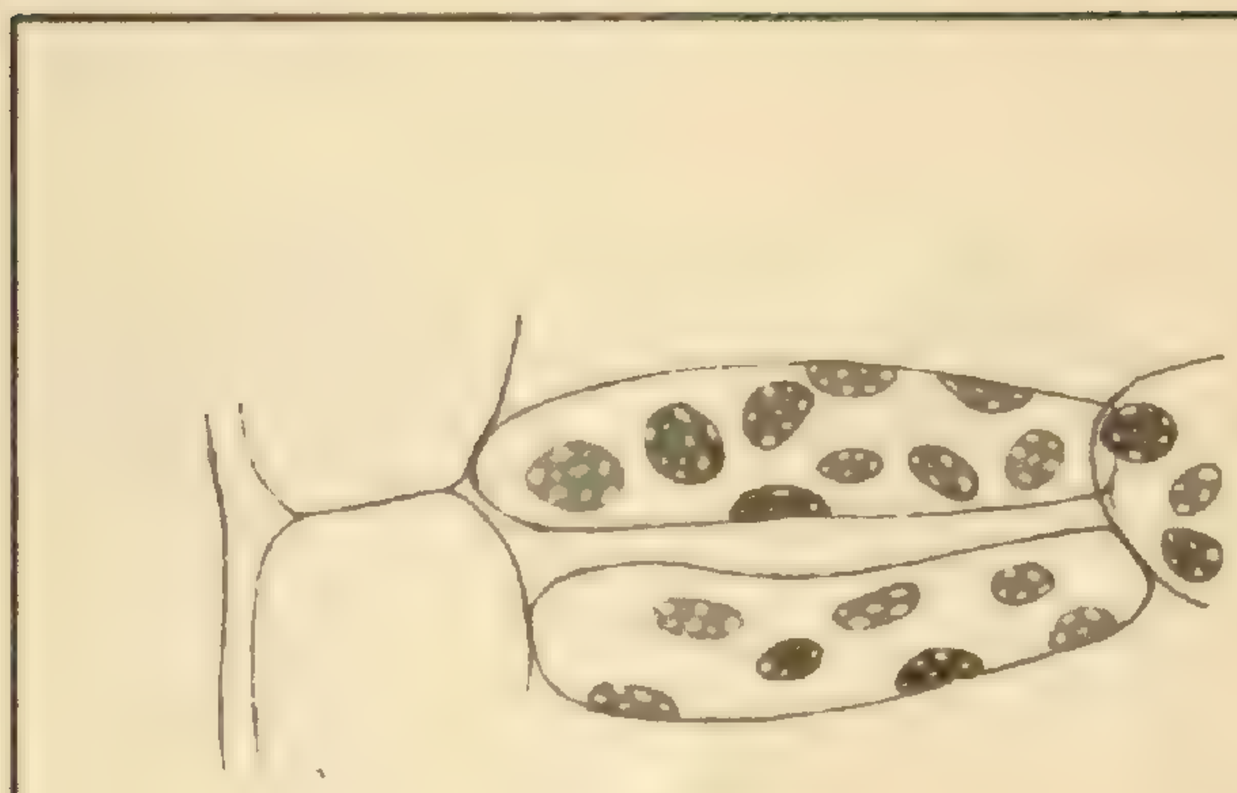
1, 2, 3. Cross-sections of diseased canes.

B, phloem; *C*, cortex; *F*, bast fiber bundles; *M*, medulla; *P*, pericyclic fibers; *R*, medullary rays; *S*, suber; *X*, xylem.



BUTLER: CALIFORNIA VINE DISEASE

BUTLER: CALIFORNIA VINE DISEASE



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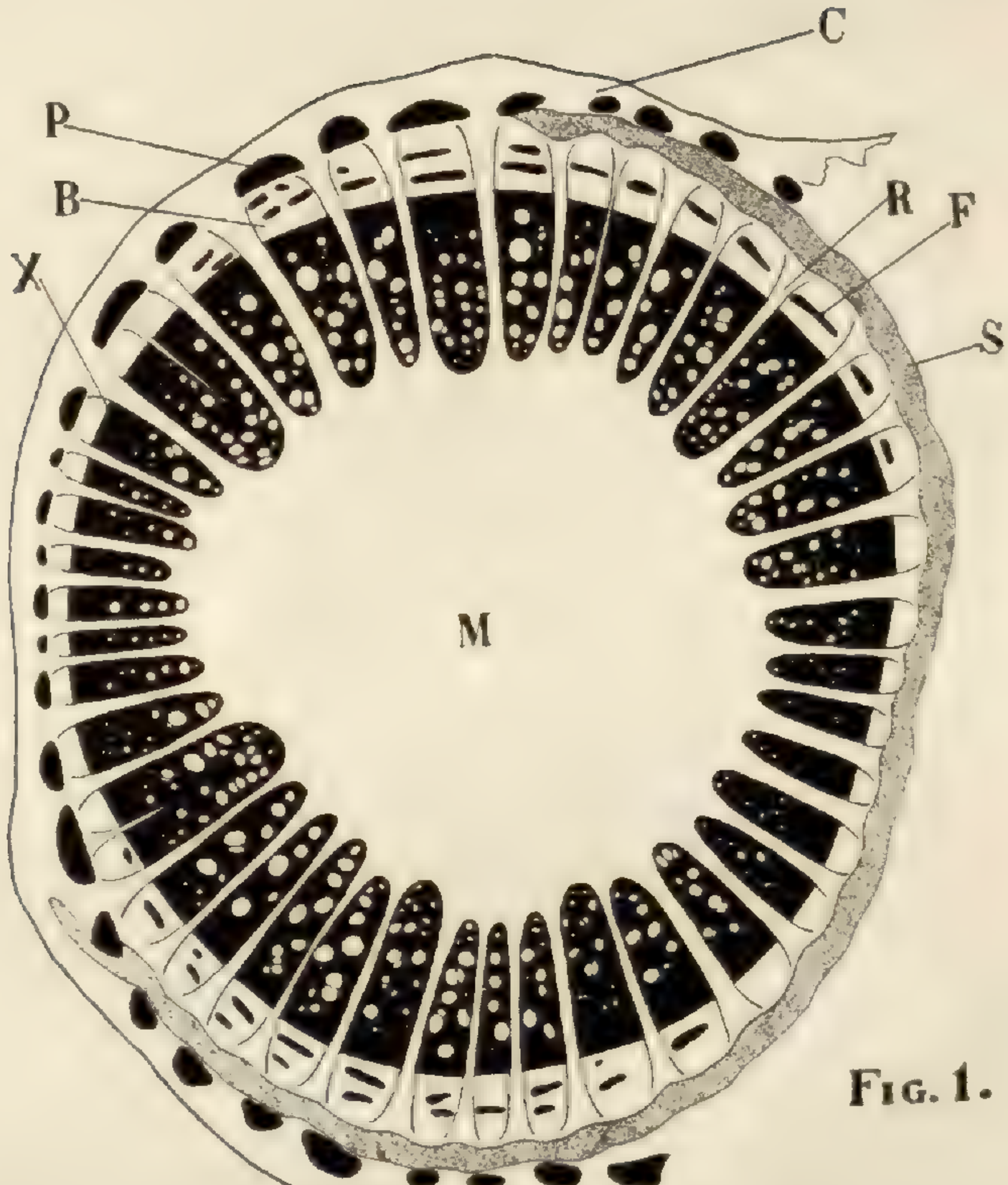

FIG. 1.

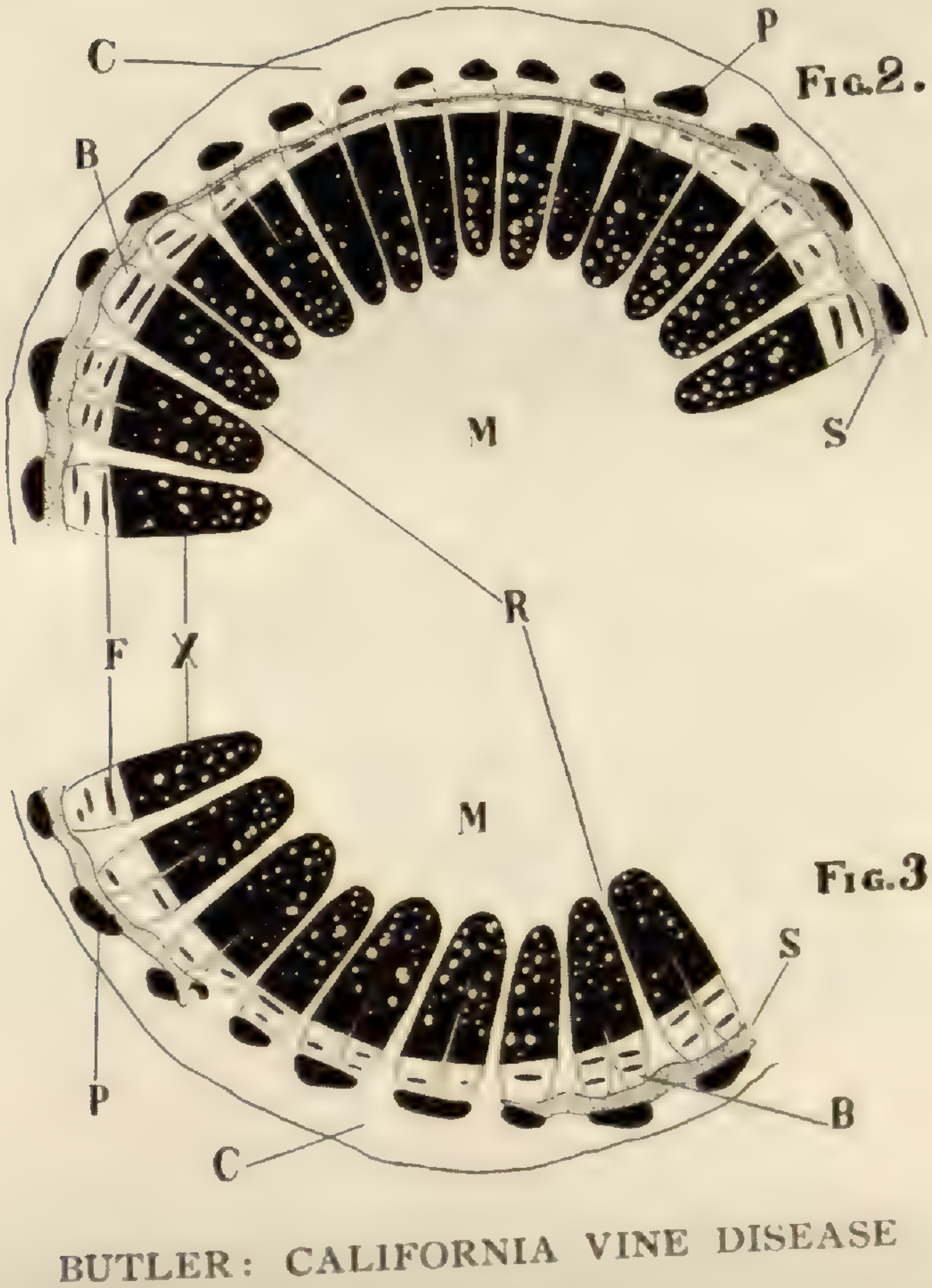

FIG. 2.

FIG. 3.

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VOL. XIV NO. 3

A MONOGRAPH OF THE GENERA CHAETOMIUM AND ASCOTRICHA

BY

A. H. CHIVERS

ISSUED JUNE 10, 1915

A monograph of the genera Chaetomium and Ascotricha*

A. H. Chivers

(WITH PLATES 6–17)

Introduction

In 1902 the writer attempted to arrange and classify a considerable number of specimens of *Chaetomium* which were then in his herbarium at Hanover, New Hampshire, and which were collected by him in various localities in New England. At that time the only available monograph was the well-known work of Zopf (113) which contained descriptions of ten species only. While it was possible to identify certain forms in the collection, others were laid aside until more information could be obtained. The study of these first collections, however, aroused so much interest that the writer was led to continue his work on these fungi, and since that time he has been engaged in the preparation of an illustrated monograph of the genus.

It became evident from further examination of the literature that no adequate work on the genus was available, and that from a systematic standpoint it had become greatly confused owing to the multiplication of species which are either synonyms, in many cases even of species not belonging to this genus, or are described without recognizable figures or full and comparative descriptions.

Some time after, when this work was well under way, a monograph of the genus by Bainier (3) appeared, in which twenty-two species and three varieties were described and illustrated, some of which proved to be American, while twelve species and two varieties were described as new. This monograph, although in some respects more comprehensive, was nevertheless like that of Zopf by no means complete. No mention was made of work by American authors or with two exceptions of English literature on the subject, while the repeated use for new species of names already preoccupied introduced a further element of confusion.

* Contributions from the Cryptogamic Laboratory of Harvard University. No. LXXVI, Memoirs of the Torrey Botanical Club, Volume 14, No. 3. [Issued June 10, 1915.]

Up to the present time there has been no further attempt to make a comprehensive review of the genus or to collate the American forms, with the exception of the revision of the Chaetomiaceae by Miss Palliser in the North American Flora, where seventeen species are enumerated including three unpublished names.

The writer feels therefore that a thorough and complete study of the subject is much to be desired, and while he cannot hope that the following revision can be final, he has spared no pains to ascertain the facts in every case so far as has been possible, and to make clear by figures and descriptions the specific characteristics of the individual species which in his opinion should be recognized.

The postponement of the final publication for a considerable time on account of unavoidable interruptions and delay caused by the preparation of plates seems in the end an advantage, for in the course of his work upon these widely distributed fungi, the writer has been able to examine a very large series of specimens from various herbaria and exsiccati, and to cultivate many species from diverse sources on various media, over long periods of time and through many successive generations. As a result of this examination, numerous forms have been added to those previously recorded from America, and a number of new species have been recognized. In this connection it may be mentioned that all of these forms, with six exceptions, have been extensively cultivated in a pure condition and that it has been possible to determine with accuracy their range of variation as well as their salient specific characteristics.

Those who have given attention to species of *Chaetomium* must be aware of the more or less unsatisfactory results to be obtained by working with dry herbarium material. Unless the specimens are carefully protected by pill boxes or other convenient receptacles, the characteristic appendages of the perithecia soon become broken, and the thin, brittle, perithecial walls disintegrate. It is the exception to find herbarium and exsiccati material thus protected. On the contrary it is most often mounted on the page with no protection whatsoever, or enclosed in paper envelopes which soon collapse and press against the plants, and it is for

these reasons that specimens are so often broken and damaged. In many cases, therefore, it is unfortunate that new species names have been freely applied to such forms as have seemed to differ from those already named, before it was determined with certainty that such differences as existed were characteristic of the living plant and not peculiar to the dry specimen. Moreover, since all species of *Chaetomium* which have come to the attention of the writer lend themselves to easy culture on various media, it would seem highly desirable that they should be carefully studied in all stages of development in order that their true characteristics may be determined.

As a result of a thorough review of the literature one hundred and fourteen species names and fourteen variety names have been found which have been applied to forms supposedly *Chaetomia*. In the present revision a considerable number of changes have been made. Names which were first used in connection with good species have been retained, while many others have been listed as synonyms thereto. For reasons given elsewhere, a considerable number have been excluded, and the writer feels that the use of such names should be discontinued. Certain new names representing new forms heretofore unrecognized have been added to the list of known species. Nevertheless according to the best judgment of the writer, the genus should include not more than twenty-eight species.

A careful study of the genus *Bommerella* has led to its inclusion under *Chaetomium*, while on the other hand *Ch. chartarum* (Berk.) Winter and *Ch. pusillum* E. & E., which possess similar characteristics, yet are markedly different from those of the typical species of *Chaetomium*, have been included in a separate genus to which the name *Ascotricha*, first given by Berkeley to the plants which Winter later renamed *Ch. chartarum*, has been applied.

In connection with his work the writer has been especially fortunate in being able to examine exsiccati in several herbaria and to study a large number of type specimens which have been generously contributed by many individuals both in this country and abroad. Sets of specimens as complete as possible and containing as many of the writer's forms as are available have been distributed to the Royal Botanic Gardens at Kew, the

Cryptogamic Herbarium at Berlin, the University of Padua, the New York Botanical Garden, and to the Cryptogamic Herbarium at Harvard University. Cultures of several species have been sent to the Centralstelle für Pilzkulturen at Amsterdam.

At this point the writer wishes to acknowledge his indebtedness to those who have aided substantially in the completion of this work; to Dr. Roland Thaxter, especially, who has at all times been ready to encourage and give freely of his time and material, and whose helpful suggestions and guidance have made this work possible; to Professor W. G. Farlow for the use of his herbarium and literature from his private library; to Professor G. F. Atkinson, Dr. J. H. Faull, Dr. L. W. Riddle, Dr. I. F. Lewis, Dr. A. F. Blakeslee, Dr. George R. Lyman, Mr. R. H. Colley, and Mr. A. T. Speare, for material for cultures; to Dr. P. A. Saccardo, Mr. George Massee, Dr. G. Lindau, Dr. Charles H. Peck, Dr. J. Dearness, Dr. P. Hariot, Dr. F. Cavara, Dr. C. H. Kauffman, Dr. L. H. Pammel, and Dr. Elam Bartholomew, for valuable type material and authentic specimens; to Mr. A. B. Seymour and to Mr. Piguet for assistance in reference work.

This investigation was begun in the Cryptogamic laboratories of Harvard University under the guidance of Dr. Roland Thaxter, and completed in the botanical laboratories of Dartmouth College.

THE GENUS CHAETOMIUM, HISTORICAL REVIEW

The contributions of a systematic nature which have been made to the genus *Chaetomium* are numerous and cover a considerable period dating back to 1817. In the brief summary which follows it will be possible to discuss only those which are most important and to call attention in a very general way to a host of minor contributions which have been made by writers little acquainted with the characteristics of the forms in this genus.

In 1817 Gottfried Kunze (**50**) published a description of a hitherto unrecognized genus and gave to it the name *Chaetomium* (χαίτωμα, a hair). It is of interest to note his characterization of the genus, since he clearly discerned some features which many later writers have disregarded, while on the other hand, he made errors in describing structures which later writers have

corrected. According to his description the perithecia were globose, membranaceous, clothed on all sides with opaque hairs, and at length became pierced by an opening at the summit. The spores were pellucid and mingled in a gelatinous mass. The fungus appeared like an inverted *Myrothecium* of Tode. The spherical or steeple-shaped fruiting body consisted of a cuticular integument, trimmed with long, mostly stiff opaque hairs enveloping a more or less globular, gelatinous mass in which spores were mixed. Under the influence of moisture the semi-transparent enclosing walls opened by a central pore and drew back more or less. The wall closed as it became dry and reopened with returning moisture. This happened as long as the perithecium contained spores.

It may be seen from the above description that Kunze saw clearly an important fact, namely that the perithecium possessed a pore through which the spores were discharged, but that on the other hand he failed to interpret aright its internal structure. It is not difficult for one acquainted with the appearance of the structure within the perithecial wall to understand how, with comparatively slight magnification, he mistook these structures for a mass of jelly and failed to discover the asci of which the mass is made up. Hence the fact that asci were present in these plants was entirely overlooked.

Ch. globosum Kze. (50) was named and described as characteristic and typical of the genus. According to his own statement Kunze was familiar with several other species of *Chaetomium*, and it was his intention to publish a monograph at a later date, but with the exception of a description of an interesting species under the name *Ch. elatum* Kze. (51) this author published nothing further on *Chaetomium*.

In spite of the fact that not less than thirteen new species were described by Ehrenberg (28), Fries (38), Wallroth (109), and Schweinitz (91) during the years immediately following Kunze's work, no contribution of value was made until 1837. Writers up to this time had not discovered the presence of asci nor had they considered the size of spores an aid to the identification of species. In many diagnoses of new forms the fact that the genus had been characterized by Kunze as possessing an ostiole seems to have been entirely overlooked.

With the publication of his Icones by Corda (**21, 22, 23**) in 1837, 1838 and 1840 came quite a new era in the history of the genus. This author amended the original description given by Kunze as follows: "Peridium membranaceous, at length opening at the apex by a pore, clothed on the outside with opaque hairs, supported by a more or less well-developed, fibrous hypothallus: spores grouped together, ascomorphic, pedicellate, at length discharged as simple powdery spores. Pedicels without mucous." It may be readily seen that from the amended description one is able to form a much more accurate judgment of the characteristics of the genus.

Corda was the first to study the internal structure which other authors had been content to call a gelatinous mass. He observed this to be made up of bodies which he called asci, though according to his description he was misled in believing that these bodies functioned as pedicels on which the spores were borne. Corda's descriptions are for the most part illustrated by figures which are elaborate for his time, and while it is not possible to determine with certainty all of the forms with which he dealt, several may be easily recognized. Of the seven new species described *Ch. indicum* and *Ch. murorum* stand out as those to be retained, while the remaining five have been referred to other genera, treated as synonyms, or excluded.

Between the time of Corda and the appearance of Zopf's monograph in 1881 descriptions of at least thirty-two new species appeared. In fact so many contributions were made that it will be possible to mention here only those which furthered the accurate knowledge of the genus. In 1849 Fries (**39**) called attention to the fact that in *Chaetomium* the spores are formed in typical asci, though the asci are rarely conspicuous. This is the first recognition of the true character of the perithecial contents which Corda had mistaken for spore-bearing pedicels and which all other writers had described as a gelatinous mass including spores. Fuckel (**42**) and Cook (**16**) also made valuable contributions in 1869 and 1873, respectively, in their descriptions of two new species under the names *Ch. crispatum* and *Ch. funicolum*.

The well-known monograph of Zopf (**113**), to which reference has been made on a preceding page, marked the appearance of a

work of an entirely different nature from that of many preceding authors, and it is only to be regretted that the monograph could not have been made more complete by its author. Zopf recognized the necessity of making descriptions clear and complete, of including details, and of presenting figures with the descriptions. It will be remembered that in his monograph Zopf divided his species into two subgenera, *Chaetomium* and *Chaetomidium*. Under the first subgenus he described as new and figured *Ch. spirale;* renamed, described, and figured Kunze's *Ch. globosum* under the name *Ch. Kunzeanum;* described and figured *Ch. murorum* Cda., *Ch. pannosum* Wallr., *Ch. crispatum* Fckl., and *Ch. indicum* Cda.; described *Ch. cuniculorum* Fckl., *Ch. elatum* Kze.; redescribed and figured his own species, *Ch. bostrychodes*, which had already appeared at an earlier date. Under the subgenus *Chaetomidium* he described and figured *Ch. fimeti* Fckl.

Since 1881, writers have for the most part been content with publishing scattered new species and varieties, and no one has attempted a complete survey of all which have appeared, or a revision of the badly confused literature. Among these forms, which number at least forty and which represent the work of nearly as many authors, two only can be regarded with certainty as good species; *Ch. contortum*, described by Dr. Peck (**67**) in 1896 and *Ch. simile*, by Massee and Salmon (**59**) in 1902. During the year 1910, however, Miss Helen L. Palliser (**65**) wrote her revision of the Chaetomiaceae of North America, and in the same year Bainier (**3**) published his monograph of the genus. The work of both these authors includes the study of a considerable number of forms.

In Palliser's revision seventeen species are enumerated, fourteen of which had previously appeared in publications of other authors. *Ch. aterrimum* is described for the first time under a name given it by Ellis and Everhart, while *Ch. cochliodes*, *Ch. spirochaete*, and *Ch. flexuosum* are described as new. At the end of her paper four species are enumerated as doubtful forms. It may be well to state here the more important differences in arrangement between Palliser's paper and that of the present writer. In Palliser's revision *Ch. caninum* E. & E. stands as a

species, rather than as a synonym of *Ch. bostrychodes* Zopf; *Ch. lanosum* Peck and *Ch. olivaceum* C. & E. appear as species, rather than as synonyms to *Ch. globosum* Kze. The name *Ch. Ellisianum* Sacc. is retained for the plant which the present writer has renamed *Ascotricha pusillua* (E. & E.); *Ch. contortum* Peck is treated as a synonym to *Ch. crispatum* Fuckel, rather than as a distinct species; *Ch. melioloides* C. & P. is recorded as a species, rather than as a synonym of *Ch. indicum* Cda.; *Ch. sphaerospermum* C. & E. is treated as a species of the genus *Chaetomium* rather than as *Ascotricha chartarum* Berk.; Winter's name, *Ch. setosum*, is retained and *Ch. indicum* of Zopf, but not of Corda, appears as a synonym thereto.

The monograph of the genus *Chaetomium* by Bainier contains a brief historical sketch and review of the work on development; a characterization of the genus; a description (with figures) of twenty-two species and three varieties, twelve species and two varieties of which are described under new names as follows: *Ch. megalocarpum*, *Ch. contortum* (not of Peck), *Ch. spirilliferum*, *Ch. undulatum*, *Ch. setosum* (not of Winter or of Ellis & Everhart), *Ch. comosum*, *Ch. glabrum* (not of Berkeley & Broome), *Ch. tortile*, *Ch. formosum*, *Ch. formosum*, var. *ovatum*, *Ch. formosum*, var. *neglectum*, *Ch. caprinum*, *Ch. torulosum* and *Ch. rigidulum*. The most striking characteristic of Bainier's monograph is the multiplication of species and the fact that several species and varieties have been made from *Ch. globosum* Kze. and *Ch. bostrychodes* Zopf, both of which are variable forms. It should here be noted that three of the names used by Bainier, viz., *Ch. contortum*, *Ch. setosum*, *Ch. glabrum*, must, if the priority rule is to be followed, be changed, since Dr. Peck had previously used the name *contortum;* Winter, and later Ellis and Everhart, had made use of the name *setosum*, and Berkeley and Broome had used the name *glabrum*.

CHARACTERS OF THE GENUS CHAETOMIUM

Perithecium superficial, spherical and translucent when young, when mature subglobose or elongated, colored and more or less opaque, pierced at the upper extremity by an ostiole. Perithecium wall membranaceous, brittle, distinctly cellular, provided with appendages in the form of variously modified hairs. Mycelium

in the form of a densely aggregated mass of fungus threads radiating in ropy strands from the point of origin. Asci thin-walled, delicate, stalked, evanescent, club-shaped or rarely linear and cylindrical, eight-spored. Spores single-celled, colored, most frequently olive-brown, typically lemon-shaped.

KEY TO THE SPECIES OF CHAETOMIUM

I. Terminal hairs unbranched.

A. Terminal hairs straight or nearly so. Spores irregularly triangular. — 1. *Ch. trigonosporum* (p. 166).

B. Terminal hairs flexuous, circinate at their tips.

Terminal hairs slender, about 4 μ in thickness, with open, circinate tips. Plant blue-gray to blue-black. — 2. *Ch. murorum* (p. 166).

Terminal hairs stout, about 7 μ in thickness, coarsely encrusted, with closed, circinate tips 2–3 times re-curved. Plant gray-black. — 3. *Ch. circinatum* (p. 168).

C. Terminal hairs tortuous, consisting of successively reversed loops with connecting arches. Tips circinate.

Terminal hairs stout, 15 μ in thickness at crown of terminal arch. Arches short and loops closely approximated. Perithecium large with diameter as great as 1050 μ. — 4. *Ch. contortum* (p. 169).

Terminal hairs slender, about 6 μ in thickness at crown of terminal arch. Arches long and graceful, loops far apart. Perithecium not exceeding 340 μ in diameter. — 5. *Ch. simile* (p. 169).

Terminal hairs rather slender, about 7.5 μ in thickness at crown of terminal arch. Arches short and loops closely approximated. Perithecium not exceeding 350 μ in diameter. — 6. *Ch. crispatum* (p. 171).

D. Terminal hairs tortuous or spirally coiled.

Terminal hairs contorted as well as intricately and irregularly spirally coiled, usually with arched circinate tips. Perithecia subglobose. Plant gray-black. — 7. *Ch. tortile* (p. 172).

Terminal hairs coiled above into a spiral of constantly decreasing diameter, the lower coils of which are large and distant, the upper ones, smaller, closely approximated. Tips not circinate. Perithecium subglobose. Plant blue-gray. — 8. *Ch. convolutum* (p. 173).

Terminal hairs more slender, finely coiled above into a spiral of small diameter which soon becomes frayed, taking on the character of a woolly thread. Perithecium elongated, barrel-shaped. Plant gray. 9. *Ch. subspirale* (p. 173).

E. Terminal hairs more or less evenly and continuously arcuate from base to incurved tip.

Terminal hairs incurved at tips, spores irregularly ovate. Plant gray, pale olive or golden yellow. 10. *Ch. aureum* (p. 174).

Terminal hairs circinate or slightly convolute at tips. Spores fusiform. Plant gray to pale olive. 11. *Ch. fusiforme* (p. 175).

Terminal hairs 1–3 spirally convolute at tips. Spores with shape of a section of an orange. Plant olive yellow. 12. *Ch. trilaterale* (p. 175).

II. Terminal hairs constantly and conspicuously branched, straight or nearly so, at least not regularly undulate or spirally coiled.

A. Terminal hairs dichotomously branched.

Terminal hairs branching by acute angles, about 6.5 μ in thickness at base. Perithecium small, not exceeding 160 μ in diameter. Plant black at maturity, gray-green in old age. 13. *Ch. funicolum* (p. 176).

Terminal hairs of two types; (*a*) stout, branching by obtuse angles with branchlets reflexed; (*b*) more slender, irregularly constricted and inflated, branching by narrow, acute angles. Perithecium not exceeding 200 μ. Plants black. 14. *Ch. indicum* (p. 178).

Hairs large, coarsely roughened, branched by obtuse or acute angles. Perithecium large with diameter as great as 500 μ. Plant greenish when young, black at maturity. 15. *Ch. elatum* (p. 180).

B. Terminal hairs never dichotomously branched.

Terminal hairs in form of stiff, spine-like shafts. Perithecia subglobose. Spores egg-shaped. Plant golden yellow. 16. *Ch. spinosum* (p. 187).

Terminal hairs much longer, collapsed and flexuous above. Perithecium extremely elongated. Plant ochraceous. 17. *Ch. ampullare* (p. 187).

III. Terminal hairs branched, with branches anastomosed forming a network. 18. *Ch. cuniculorum* (p. 188).

IV. Terminal hairs branched but not regularly or conspicuously so, undulate or spirally coiled.

A. Terminal hairs undulate or loosely, spirally coiled.

Terminal hairs undulate, extremely fine and delicate, yellow, frequently branching several times. Perithecium globose below, narrow above. Plant gray or olive yellow, at maturity golden yellow. 19. *Ch. sphaerale* (p. 189).

Terminal hairs undulate or loosely spirally coiled. Branches few. Plant gray, olive-green or chocolate-brown. 20. *Ch. globosum* (p. 190).

B. Terminal hairs convolute in definite spirals.

a. Perithecia gray when young, becoming black in old age.

x. Perithecia subglobose or ovate.

Terminal hairs slender, about 5 μ in thickness near their tips, with 6–14 coils. Spores large, 9 × 7 μ, rich olive-yellow to olive-brown. 21. *Ch. spirale* (p. 199).

Terminal hairs stout, about 9 μ in thickness near tips with 10–18 coils. Spores olive-brown, 7 × 6 μ. 22. *Ch. aterrimum* (p. 200).

Terminal hairs regularly coiled with 5–7 convolutions, or irregularly coiled with 2–3 loose convolutions, frequently producing branches. Spores elliptical in face view, hyaline or only slightly colored, 7.4–6 μ. 23. *Ch. bostrychodes* (p. 201).

y. Perithecia elongated.

Spores in face view four-sided and four-angled. 24. *Ch. quadrangulatum* (p. 202).

Spores lemon-shaped or globose. 25. *Ch. caprinum* (p. 203).

b. Perithecia green or golden yellow.

x. Perithecia subglobose or ovate.

Terminal hairs of two types; (*a*) stout, straight below, with three or four convolutions near tip; (*b*) slender, delicate, either coiling in spirals or twisting irregularly. Plant olive-green. 26. *Ch. cochliodes* (p. 204).

Terminal hairs of three types; (*a*) long, straight, tapering; (*b*) slender, straight below, coiling above spirally with about 5–7 convolutions; (*c*) stout, coarse, straight below, spirally coiled above with about 2–3 convolutions, frequently branched. Plant olive-green. 27. *Ch. angustum* (p. 206).

y. Perithecia elongated, bottle-shaped.

Terminal hairs constricted at the septa, straight below, collapsed, irregularly undulate and branched above. Plant golden-yellow. 28. *Ch. torulosum* (p. 207).

1. **Chaetomium trigonosporum** (Marchal) comb. nov.

Bommerella trigonospora Marchal, Bull. Soc. Roy. Bot. Belgique **24**: 1. 1885; **28**: 261–271. *pl. 10.* 1889.

PLATE 6, FIGS. 6–11

Black. Perithecia of medium size, globose or subglobose to somewhat elongated, 315 × 221 μ (250–340 × 160–262), provided with long, slender, straight or curved, black cirrhi, seated on a mat of hyphae which are olive-yellow to olive-brown. Lateral hairs rather numerous, comparatively short, spine-like, tapering, below dark olive-brown, minutely roughened, conspicuously and evenly septate, at base about 4.7 μ in thickness; above faded, pale yellow, obscurely septate, smooth, near tip colorless. Terminal hairs straight, unbranched, longer than the lateral ones, dark rich olive, regularly septate to near the tips, smooth or only slightly and obscurely roughened, at base about 4.7 μ in thickness, at tip pale yellow or colorless, without septa. Asci narrowly and irregularly club-shaped, 8-spored, 50 × 8 μ, pars sporif. 32 μ. Spores when young greenish and filled with highly refractive globules, when mature rich olive-yellow to dark olive-brown, in face view irregularly triangular, 8.9 × 5.7 μ (8.1–9.7 × 4.8–6.4), when seen edgewise nearly oval, 3.6–4 μ broad.

On rabbit dung, North Carolina, Herb. R. Thaxter (Chivers No. 6). Type locality: in heath near Aerschot, Belgium; on dung of hare.

So far as the writer is aware this is the only form with straight, unbranched, terminal hairs to be included in this genus. The species has been grown in varied cultures for many years and seems to be a true *Chaetomium* both in its life history and specific characteristics. While the spores which are here roughly triangular differ in shape from those of the greater number of species, the variation is no greater than in those of *Ch. quadrangulatum* where they are four-sided and four-angled.

2. CHAETOMIUM MURORUM Corda, Icones **1**: 24. *pl. 7, f. 293B.* 1837; Icones **2**: 29. *pl. 13, f. 103.* 1838

Chaetomium comatum, var. *helicotrichum* Saccardo, Michelia **1**: 222. 1878.

Chaetomium griseum Cooke, Grevillea 1: 175. 1873.

PLATE 8, FIGS. 6–10

Blue-black. Perithecia of medium size, globose or ovate with a bluntly pointed base, 278 × 267 μ (243–337 × 206–337). Lateral hairs long, graceful, flexed, insensibly tapering to a point, delicate when young, when mature about 7.5 μ in thickness, dark olive-brown near base, gradually fading at tip, conspicuously granular-roughened, or nearly smooth, clearly or obscurely septate. Terminal hairs variable with age; when young stout, about 5.5 μ in thickness at the middle of their length, not circinately curved at tips, but broadly arched throughout their length; at maturity slender, about 4 μ in thickness, gracefully flexed or nearly straight, ending in a graceful arch with circinate tip, dark rich olive-brown, sparsely and irregularly septate, smooth or roughened by irregular projections, in old age becoming still darker, frequently losing their circinate tips and tending to become wavy throughout. Asci broadly and irregularly club-shaped, 8-spored, 53 × 19 μ, pars sporif. 34 μ. Spores filled with greenish refractive globules when young, when mature dark olive-brown, globose-ovate to narrow elliptical, apiculate at both ends or apiculate at one end and umbonate at the other, frequently collapsing by a longitudinal furrow, 12.6 × 8.1 μ (11.3–12.9 × 8.1), when seen edgewise, compressed, 6.4 μ broad.

EXSICCATI.—Fung. Europ., Series II, Edit. nova, III, 234. Sub *Ch. Kunzeanum* Zopf: Fung. Gall. XLV, 4436.

This species is extremely common, growing on dung of various animals, especially on dog dung, and on very varied substrata from all parts of New England (Chivers No. 13). Reported also from Montana, by Ellis and Everhart (Anderson No. 651); from England, by Massee and Salmon; and from Germany, by Zopf. Type locality: Prague; on damp walls.

It may be seen from the above that *Ch. griseum* described by Cooke in 1873 and *Ch. comatum*, var. *helicotrichum* by Saccardo in 1878 are considered as synonyms of Corda's species. A careful study of the former has been made from type material received from the Royal Botanic Gardens at Kew and the characteristics noted seem to agree in every way with those of *Ch. murorum*, though Cooke stated that the threads of his species were stouter and the spores larger and colorless. Through the kindness of Dr. Saccardo it has also been possible to examine

type specimens of his variety and while he found a similarity to *Ch. murorum* only in the circinate tips of the hairs, the present writer has found all the characteristics of the plants examined to be typical of Corda's species. On the contrary there seem to be no reasons for considering the form related in any way to *Ch. comatum*, since the hairs are not branched.

Only *Ch. elatum* Kze. could be obtained from exsiccati specimens in Rabenhorst's Fungi Europaei No. 234.

Ch. murorum Cda. may at first sight be confused with *Ch. circinatum*, but may easily be distinguished from it by the smaller diameter of the terminal hairs which are only 5.5 μ in thickness, and which are flexed not sinuous, slightly if at all recurved at their tips, and more minutely and inconspicuously roughened.

3. **Chaetomium circinatum** sp. nov.

PLATE 8, FIGS. 1–5

Gray-black. Perithecia of medium size, ovate or globose, 325 × 312 μ (270–344 × 258–335). Lateral hairs long, flexed, graceful, sparsely and irregularly septate, at base olive-brown, roughened, 5.6 μ in thickness, at the apex smooth, pale olive, slender. Terminal hairs dark, nearly opaque, olive-brown or brownish-black, sinuous, 7 μ in thickness, at the base irregularly encrusted, at the apex smooth or only slightly encrusted, circinate, two to three times re-curved. Asci irregularly club-shaped, 8-spored, 70 × 25 μ, pars sporif. 50 μ. Spores ovate or lemon-shaped, apiculate or umbonate, olive-brown, 14.3 × 8.9 μ (12.9–15.3 × 8.1–9.7).

A rare species having appeared only once on a piece of old burlap in a refuse heap, Worcester, Massachusetts (Chivers No. 12).

This species, while similar in certain respects to *Ch. murorum*, may be easily distinguished from it by the characteristic terminal hairs which are sinuous instead of flexed, roughened by crystals of calcium oxalate, which are irregularly clustered along their entire length, circinately recurved at the tips, the last coil of which often springs out to one side or the other from the plane of coiling.

4. CHAETOMIUM CONTORTUM Peck, Rep. New York State Mus. Nat. Hist. **49**: 24. 1896

PLATE 9, FIGS. 10–12

Black. Perithecia large, globose or subglobose, 875 × 1050 μ. Lateral hairs numerous, straight or flexed, clearly septate, smooth, some with equal diameter and olive-yellow throughout, others thicker (about 5.6 μ) and dark olive-brown at base, gradually tapering and fading toward tip. Terminal hairs dense olive-brown to black, without visible cross walls, roughened throughout with blunt, flat-topped projections, nearly straight below, contorted above into loops which are separated by short, abrupt arches, terminating in an arch with circinate, recurved tip, 15 μ in thickness at the crown of the terminal arch. Asci "fugacious." Spores when young hyaline, refractive, filled with refractive globules, when mature dark rich olive-brown, irregularly lemon-shaped, not always symmetrical, sometimes apiculate at ends, sometimes barely angular, 11.6 × 9.4 μ (10.5–12.5 × 7.5–10.5).

So far as the writer is aware this species has never been found except in the type locality: Woodside, New York; on bulbs of lilies, *Lilium longiflorum* (F. C. Stewart).

On account of the fact that only two mounts of the type material received from Dr. Peck have been available, it has been impossible to determine the characteristics of the asci, for although the perithecium in one mount was broken and the young asci were exposed, they could not be accurately studied. It has seemed desirable, therefore, to quote from the original description regarding the asci.

This species has certain features in common with *Ch. crispatum*, *Ch. simile*, and *Ch. tortile*. From the first it differs in the greater dimensions of the perithecium, and the greater width and more regular looping of the terminal hairs. From *Ch. simile* it differs in the greater dimensions of the perithecium, the greater width and more compact looping of the terminal hairs and the greater size of its spores. From *Ch. tortile* it differs in the greater dimensions of the perithecium, in the greater width and more regular looping of its terminal hairs and the greater size of its spores.

5. CHAETOMIUM SIMILE Massee & Salmon, Ann. Bot. **16**: 71. *pl. 4, f. 8, 9.* 1902

Chaetomium glabrum Bainier, Bull. Soc. Myc. France **25**: 214. *pl. 21, f. 1–4.* 1910.

PLATE 9, FIGS. 1–4

Dark gray to black. Perithecia of medium size, globose or subglobose, frequently of greater diameter horizontally, 231–295 × 231–337 μ. Lateral hairs not differentiated, but appearing about the perithecium as a tomentum of yellow, semi-transparent, fine and delicate mycelial threads. Terminal hairs dense olive-brown to black, with low power smooth, but with immersion lens irregularly thickened with extremely minute spines, irregularly and sparsely septate, nearly straight below, contorted above into loops which are separated by long, graceful arches, terminating in an arch with circinate tip, 5.6–7 μ in thickness at the crown of the terminal arch. "Asci cylindrical, about 80 × 9–10 μ, 8-spored." Spores monostichous, when young hyaline, filled with refractive greenish globules, when mature dark rich olive-brown, subglobose or very broadly elliptical, some clearly apiculate at one end, barely so at the other, others apiculate only at one end and rounded at the other, 10 × 8 μ (9.5–10.5 × 7.5–8.9), when seen edgewise, compressed, 6.4 μ broad.

Type locality: Kew, England; on dog dung.

Although it has been impossible to examine type material of the plant which Bainier found on dog dung and described under the name *Ch. glabrum* in 1910, the writer is convinced that it is identical with *Ch. simile*. The measurements of the perithecia and spores are the same for both species and the development of the dark area near the top of the perithecium which Bainier noted as unusual appears in all species of *Chaetomium* where the wall remains so transparent that the darkened spore mass may be seen.

Through the kindness of the Royal Gardens at Kew the writer has been enabled to study type specimens of *Ch. simile*, but as no asci could be found in mounts made from this material, the original description has been quoted and the figure of the ascus has been copied.

At first sight one may confuse this species with *Ch. contortum*, *Ch. crispatum* and *Ch. tortile*. It differs from these, however, in the terminal hairs which are of much smaller diameter and which form long, graceful arches between their loops. It differs also from *Ch. contortum* in the smaller size of the perithecium and from both *Ch. contortum* and *Ch. crispatum* in its slightly smaller spores.

6. CHAETOMIUM CRISPATUM Fuckel, Symb. Myc. 90. 1869

Sphaeria crispata Fuckel, Fung. Rhen. 2022. 1867.

Chaetomium streptothrix Quélet, Mém. Soc. d'Emul. Montbeliard 1875: 103. *pl. 4, f. 40.* 1876.

PLATE 9, FIGS. 5–9

Gray to gray black. Perithecia of medium size, globose or subglobose with a bluntly pointed base. 263 × 253 μ (198–320 × 183–350). Lateral hairs numerous, straight or slightly flexed, long, slender, gradually tapering to a point, smooth, regularly septate, about 4 μ in thickness and dark olive-brown at base, fading to yellow and becoming colorless near the tip, frequently breaking at maturity and giving to the surface of the perithecium a coarse, rough appearance. Terminal hairs dense olive-brown to black, rather evenly roughened with minute spines throughout, below about 4 μ in thickness, straight or slightly curved, septate, twisting or coiling above into an irregular spiral, near the tip forming alternate loops and arches, ending in an arch with circinate tip, irregularly and obscurely septate above, enlarging to 7.5 μ in thickness at the crown of the terminal arch. Asci 8-spored, long, narrow, cylindrical, 80–100 × 8–10 μ, pars sporif. 65–80 μ. Spores monostichous, hyaline and filled with greenish refractive globules when young, when mature, dark rich olive-brown, lemon-shaped, apiculate at both ends or broad and apiculate at one end and slightly more pointed and less conspicuously apiculate at the other, 11.7 × 8.8 μ (11.3–12.1 × 8.1–9.7), when seen edgewise, compressed, lenticular, 6.4 μ broad.

This species has been found frequently on various substrata from different localities in New England (Chivers No. 9). Reported also from England, and various localities in Europe. Type locality: in the cellar of L. Fuckel; on rotting potatoes.

EXSICCATI.—Fung. Sax. XXIV, 1167. Sub *Sphaeria crispata* Fuckel: Fung. Rhen. 2022.

In 1876 Quélet described under the name *Ch. streptothrix* fungi which he found on rotting potatoes and which he thought might be the ascosporic stage of *Peronospora infestans*. While there are no figures accompanying his brief and somewhat indefinite description, it seems probable that it is identical with Fuckel's species for the following reasons: the hairs are described as tortuous, the specimens were found on rotting potatoes, a place where one is peculiarly likely to find *Ch. crispatum*, and the name which he gave indicates the same type of twisted hairs.

Ch. crispatum differs in its peculiarly contorted terminal hairs from all other species which the writer has studied, with the exception of *Ch. contortum*, *Ch. simile* and *Ch. tortile*. It has a smaller perithecium and terminal hairs of much smaller diameter and with more irregular coilings than in *Ch. contortum*; terminal hairs of slightly greater diameter and with much more irregular coilings, and spores of greater diameter than in *Ch. simile*; a smaller perithecium, more regularly contorted hairs and larger spores, than in *Ch. tortile*.

The writer has seen specimens of the exsiccati mentioned above and has made and examined mounts from them.

7. CHAETOMIUM TORTILE Bainier, Bull. Soc. Myc. France 25: 214. *pl. 22.* 1910

PLATE 9, FIGS. 13–17

Gray black. Perithecia of medium size, globose or subglobose with a bluntly pointed base, 312 × 290 μ (228–350 × 228–319). Lateral hairs numerous, 3.8 μ in thickness, dark olive-brown at base, fading to hyaline at the tips, septate, smooth throughout, often breaking at maturity leaving their bases which give to the perithecium wall a coarse, rough appearance. Terminal hairs dark olive-brown to black, roughened with minute spines, irregularly and sparsely septate, about 5.6 μ in thickness at the middle of their length, nearly straight or flexed below, intricately contorted above, at times coiling into a regular spiral, then twisting in the opposite direction forming a series of congested coils which may be thrown out of line with the main axis, terminating in an irregular or regular spiral, or in a loop followed by an arch with circinate tips. Asci long, cylindrical, 8-spored, 100 × 8–10 μ, pars sporif. 50–60 μ. Spores monostichous, hyaline when young, when mature dark, rich olive-brown, subglobose or very broadly elliptical, varying from clearly apiculate to obscurely angular, 8 × 6.5 μ (7.5–9 × 6–6.8).

On rabbit dung, Hanover, New Hampshire (Chivers No. 11). Type locality: Bainier makes no mention of the place where he found this species or the substratum on which it grew.

Ch. tortile is in certain respects similar to *Ch. contortum*, *Ch. crispatum*, and *Ch. simile*. The terminal hairs are much more complicated in their twistings than in those of the other species mentioned and more slender than those of *Ch. contortum*. The spores are smaller than those of *Ch. contortum* or *Ch. crispatum*.

8. CHAETOMIUM CONVOLUTUM Chivers, Proc. Am. Acad. 48: 85. 1912

PLATE 14, FIGS. 9–12

Blue-gray. Perithecia of medium size, globose or subglobose, 244 × 232 μ (236–254 × 224–240), frequently provided with cirrhi, destitute of differentiated rhizoids. Lateral hairs comparatively few in number, graceful, tapering, straight, regularly and distinctly septate, at base rich yellow, minutely roughened and varying from 3.5–5.6 μ in thickness, above fading and tapering to a long hyaline, frequently shriveled tip without septa. Terminal hairs forming a broadly spreading head, dark olive to black, regularly and thickly covered with minute spines and globular projections, irregularly and obscurely septate, straight below, spirally coiled above, the convolutions of which, numbering 8–10, are open and of large diameter below, but toward the extremity constantly and evenly decrease in size and become more and more closely appressed. Asci club-shaped, 8-spored, 56.4 × 10 μ, pars sporif. 27.4 μ. Spores when young colorless with granular contents, when mature, pale dull olive, ovate or lemon-shaped, bluntly pointed at either end, slightly apiculate, 8–8.4 × 6.4 μ, when seen edgewise, 4.8–5.6 μ broad.

Cultivated on mouse dung from Germany (Chivers No. 18).

This is a rare form, having appeared but once. The species may be identified by the distinct blue color of the plant when seen with the naked eye or hand lens, and by the long, spreading and drooping, terminal hairs, the long series of coils tapering abruptly to a blunt point.

9. CHAETOMIUM SUBSPIRALE Chivers, Proc. Am. Acad. 48: 84. 1912

PLATE 13, FIGS. 12–17

Gray, or gray with pink tint. Perithecia rather large, elongated, somewhat barrel-shaped, 314 × 213 μ (300–337 × 206–224), provided at maturity with an irregular blue-black spore mass which almost entirely conceals the terminal hairs, producing at or near the base a heavy, dense mass of olive-brown to black rhizoids. Lateral hairs numerous, only very slightly tapering, slender, graceful, comparatively short, regularly and distinctly septate, smooth, near base dark olive and about 3.7 μ in thickness, straight, above fading and becoming extremely refractive, twisting near the end into a very small and tightly coiled spiral. Terminal hairs slender, graceful, obscurely septate, smooth,

below dark olive, straight and about 3.7 μ in thickness, above fading to light olive-yellow or becoming colorless, and spirally coiling at first tightly, finally becoming extended and drawn out into a twisted thread. Asci club-shaped, 8-spored, 45 × 9.7 μ, pars sporif. 24 μ. Spores pale olive, lemon-shaped, apiculate at both ends, 6.4 × 5.2–5.6 μ.

Frequent in cultures of various substrata from New England. Appearing in cultures of dung from Holland and South America (Chivers No. 27).

This species may be easily distinguished by its characteristic hairs; the lateral ones being short, straight, dark below, tightly coiled into a spiral of small diameter, hyaline and refractive at the tips; the terminal ones slender, at first tightly coiled into a fine delicate spiral, later elongated, twisted rather than coiled, and giving the appearance of woolly threads.

10. CHAETOMIUM AUREUM Chivers, Proc. Am. Acad. 48: 86. 1912

PLATE 11, FIGS. 12–17

Gray, pale olive, becoming yellow, at length golden-yellow. Perithecia minute, globose or subglobose, often bluntly pointed at the base, 127 × 115 μ (110–140 × 105–123), without differentiated rhizoids, provided with a long, slender, arched or recurved cirrhus. Lateral hairs numerous, slender, straight or flexed, regularly and distinctly septate, olive-yellow, minutely roughened, with nearly equal diameter throughout, 3.5 μ in thickness, broadly arched at tips. Terminal hairs olive-yellow, regularly septate, minutely roughened, straight or slightly re-curved, at base about 3.8 μ in thickness, at tip nearly straight or incurved. Asci club-shaped, 8-spored, 42 × 10 μ, pars sporif. 26 μ. Spores when young filled with refractive globules, when mature olive-brown, irregularly ovate, apiculate at both ends, 9.8 × 5.4 μ (9.4–11 × 4.7–5.6).

On paper, dung and other materials of various kinds from New England (Chivers No. 1). In cultures of old paper from Java (R. Thaxter).

The small size and characteristic golden yellow color clearly distinguish this species from all others except *Ch. trilaterale* and *Ch. fusiforme*. From the former of these it differs in that the spores are discharged in long black cirrhi, in the comparative obscurity of the perithecial hairs at maturity, in the incurved

tips of the terminal hairs, and in the irregular, oval shape of its spores. From the latter species it differs also in producing long, black cirrhi, in the incurved extremities of its terminal hairs and in the size of its spores and their irregular oval shape.

The name of this species suggests the characteristic golden-yellow of the mature plant, but the color usually disappears as the plants grow old or as they are dried for herbarium specimens, and the highly colored perithecium becomes black. Moreover the cirrhi of spores are frequently so long that they overturn the perithecium.

11. CHAETOMIUM FUSIFORME Chivers, Proc. Am. Acad. 48: 87. 1912

PLATE 11, FIGS. 7–11

Gray or pale olive. Perithecia minute, globose or ovate with a bluntly pointed base, 120 × 102 μ (116–123 × 101–125), without cirrhi, producing at base a few yellow rhizoids. Lateral hairs numerous, slender, flexed, not spirally convolute, regularly and distinctly septate, olive-yellow, minutely roughened, about 2.5 μ in thickness at base. Terminal hairs stouter and more darkly colored than the lateral hairs, minutely roughened, olive-brown, regularly and distinctly septate, nearly straight or incurved, about 3.7–4 μ in thickness at base, at tip circinate or slightly convolute. Asci club-shaped, 8-spored, 48 × 11 μ, pars sporif. 32 μ. Spores when young filled with refractive globules, when mature olive-yellow or olive-brown, long, narrow, somewhat fusiform, round or apiculate at the ends, 15.8 × 5.4 μ (15–16 × 4.8–5).

A rare species having appeared only once on paper from Alabama, Herb. R. Thaxter (Chivers No. 3).

The long narrow spores distinguish this form from all other species of *Chaetomium*. In general characteristics it most nearly resembles *Ch. aureum* and *Ch. trilaterale*, but differs from both in the long, slender, fusiform spores.

12. CHAETOMIUM TRILATERALE Chivers, Proc. Am. Acad. 48: 87. 1912

PLATE 11, FIGS. 1–6

Olive-yellow. Perithecia minute, globose or ovate with a bluntly pointed base, 106 × 94 μ (100 × 90–97), without cirrhi

or differentiated rhizoids. Lateral hairs numerous, graceful, rather long, regularly and distinctly septate, golden-yellow, at base straight, minutely roughened and about 2.8 μ in thickness near tips, smooth and 1–3 spirally convolute. Terminal hairs stouter and more darkly colored than the lateral ones, dark olive-yellow, minutely roughened, lower portion about 4 μ in thickness, plainly septate, strongly curved, at tips 1–3 spirally convolute with scattered septa. Asci club-shaped, 8-spored, 50 × 9.5 μ, pars sporif. 26 μ. Spores when young hyaline with obscure globules, when mature rich olive-yellow to olive-brown, having the shape of a section of an orange, slightly apiculate at both ends, 9.5 × 5.5 μ (8.9–9.7 × 5.2–6).

This species has appeared only once, on paper, from New England, Herb. R. Thaxter (Chivers No. 2).

This species has certain characteristics in common with *Ch. aureum* and *Ch. fusiforme*. From the former it differs in the more numerous, stout, 1–3 spirally convolute, terminal hairs; the spirally coiled lateral hairs; the smaller size and unusual shape of the spores. From the latter species it differs in the convolute lateral hairs, the shape of its spores and their smaller size.

13. CHAETOMIUM FUNICOLUM Cooke, Grevillea 1: 176. 1873

Chaetomella Cavallii Mattirolo; Savoia, Il Ruwenzori 1: [3]. *pl. 3, f. 1–3*. 1909.

Chaetomium Bartholomaei Saccardo & Sydow; Saccardo, Syll. Fung. 14: 490. 1899.

Chaetomium setosum Ellis & Everhart, Am. Nat. 31: 340. 1897.

PLATE 7, FIGS. 9–19

Black. Perithecia small, ovate to globose, 149 × 147 μ (130–157 × 130–158), firmly attached to the substratum by dark olive to black rhizoids, frequently provided with long, straight or curved cirrhi. Lateral hairs comparatively numerous, smooth or irregularly roughened by short, blunt projections, stiff, spine-like, dark olive-brown to black nearly to tip, hyaline and crumpled at tip, rarely and obscurely septate, about 4 μ in thickness at base. Terminal hairs forming an especially dense, compact head, dichotomously branched with narrow, acute angles, frequently alternately constricted and inflated throughout, roughened over entire length by spines and irregular projections, near base dark olive-brown to black and about 6.3 μ in thickness,

fading to light brown, pale olive, or colorless tips, at maturity bearing on the most remote branches clusters of refractive needles. Asci club-shaped, 8-spored, 33.7 × 8.1 μ, pars sporif. 16 μ. Spores when young greenish hyaline, refractive, filled with globules, when mature dark, rich, olive-brown, egg-shaped to lemon-shaped, slightly more pointed at one end, apiculate at both ends, 6.3 × 4.7 μ (5.6–6.4 × 4–4.8).

EXSICCATI.—Sub *Ch. setosum* Ell. & Ev.: Fung. Columb. XII, 1126; N. A. F. 2d Ser. XXXV, 3423.

A rather common species, having been found in cultures of brazil nuts at Cambridge, on straw from Nairobi, Congo, on corn stalks from Cambridge, and on old fruit from Germany (Chivers No. 16). Reported by Peck on an old broom at Albany, New York. Reported also as *Ch. setosum* E. & E. by Ellis, and as *Chaetomella Cavallii* by Mattirolo on paper. Type locality: British Museum; on twine (W. Carruthers).

The writer is indebted to the Royal Botanic Gardens at Kew for type specimens of this species which was first described by Cooke in 1873 as *Ch. funicolum* or "Twine Bristle Mould," and which has since been found and reported by several writers in various localities. Although the species seems to have been clearly characterized by Cooke, Ellis (**35**) redescribed it in 1897 under the name *Ch. setosum*, in apparent ignorance of the fact that Winter (**112**) had previously used this combination for an entirely different plant. Authentic specimens examined in the exsiccati mentioned below are found to be identical with *Ch. funicolum* Cooke. In 1901 Saccardo changed the name to *Ch. Bartholomaei* in honor of the collector who sent the specimens to Ellis.

Although no specimens have been available the writer is convinced that the plants which M. Mattirolo (**61**) described and figured in 1909 under the name *Chaetomella Cavallii* are identical with Cooke's species. It was discovered in considerable numbers on a piece of paper which wrapped some moss. Mattirolo stated that, considering the present confusion of literature in the genera *Chaetomella* and *Chaetomium*, he thought it best to assign his species to the genus *Chaetomella*. In spite of every attempt, he could not determine whether the spores were produced in true perithecia or pycnidia or whether in an ascus or on a basidium. His three figures show a young perithecium, a branched terminal

hair, and several spores, all of which are identical with corresponding structures in *Ch. funicolum* Cke.

This species may be confused on the one hand with *Ch. elatum* from which it differs by the small size of its perithecium and spores. On the other hand it will be confused with *Ch. indicum*. In *Ch. funicolum* the perithecium during its early development is clothed throughout with long, straight, stiff, black, spine-like hairs which are more conspicuous than in *Ch. indicum* and whose tips frequently appear above the mass even at maturity. Later the terminal hairs (of one type only) grow up, branching by narrow, acute angles, until a compact head is formed. The greenish-gray and powdery appearance of the plants is due in part to the large number of colorless hair tips and also to the bundles of crystals on the ultimate branches. These characteristics, present also in *Ch. indicum*, make it more difficult to separate the two species.

14. CHAETOMIUM INDICUM Corda, Icones **4**: 38. *pl. 7, f. 104.* 1840

Chaetomium melioloides Cooke & Peck; Peck, Rep. New York State Mus. Nat. Hist. **27**: 106. 1875.

Chaetomium setosum Winter, Hedwigia **26**: 16. 1887.

PLATE 7, FIGS. 1–8

Black. Perithecia small, globose to verruciform, 180 × 160 μ (105–200 × 101–175), firmly attached to the substratum by dark olive-brown to black rhizoids. Lateral hairs comparatively few, rather rigid, septate, tapering to a blunt point or drawn out into a long, hyaline, collapsed tip, at base dark olive-brown to black, and about 5.3 μ in thickness. Terminal hairs of two types which can best be clearly distinguished by studying the perithecium at different ages; (*a*) hairs which first appear from the top of the perithecium and which do not form a dense mass, stout, dichotomously branched with branches reflexed and roughened by spine-like projections, at base dark olive-brown to black and about 7.5 μ in thickness, fading only slightly or becoming hyaline at the terminal branches; (*b*) hairs which appear later, forming at first a tuft about the ostiole, profusely branched by narrow acute angles, branches never reflexed, alternately constricted and inflated, light olive-brown or yellow, finely roughened, terminal branchlets encrusted with clusters of acicular or prismatic crystals.

Asci club-shaped, 8-spored, 30 × 9.4 μ, pars sporif. 16.5 μ. Spores hyaline when young and filled with refractive greenish globules, when mature dark, rich olive-brown, ovate to lemon-shaped, slightly apiculate at one or both ends, 5.5 × 4.5 μ (5.3–7 × 4.5–5.6), when seen edgewise, compressed, 4.2 μ broad.

On culture in laboratory, Cambridge, Massachusetts, R. Thaxter (Chivers No. 14). Reported by Spegazzini from Parque de la Plata, Argentine, and by other authors from France and Germany. Reported also as *Ch. melioloides* by Cooke and Peck, on old stems of Indian corn, North Greenbush, New York, and as *Ch. setosum* by Winter on branches of *Berberis buxifolia* in Patagonia. Type locality: India, Tenasserim, Maulmain; on rotten paper (Dr. Helfer).

While this species seems to have been clearly described and figured by Corda, it has since been re-described by Cooke and Peck in 1875 as *Ch. melioloides*, and by Winter in 1887 as *Ch. setosum*.

The writer must here acknowledge his indebtedness to Dr. Charles Peck for his generosity in furnishing specimens of *Ch. melioloides* as well as several other of his species. In answer to inquiry regarding the possible identity of *Ch. melioloides* with Corda's *Ch. indicum*, Dr. Peck kindly sketched with a camera typical hairs and spores, and wrote as follows: "The two species certainly run close together and if I were inclined to overlook small differences I could easily make myself believe that they are forms of one species. I notice, however, that the spores of *Ch. indicum* are more elliptic as required by the description of the species, and that they run a little longer than in our plant. But I never would think of describing them as acute at each end. Can this be a mistake in the description or is it due to culture modifications?" After a very careful examination of the two plants, the present writer is convinced that the two are identical and that Dr. Peck's name should appear as a synonym to *Ch. indicum*. The hairs as sketched by Dr. Peck and the spores as studied in mounts from the type specimen are typical of Corda's species.

Through the kindness of M. Hariot the writer has been able to study *Ch. setosum* Winter, and it has been found that the plant thus named is identical in every way with *Ch. indicum* Cda. It produces the same dichotomously branched hairs with widely

spreading branchlets, and spores of the same shape and size. The statement made by Palliser in North American Flora (p. 63), where *Ch. indicum* Zopf is listed as a synonym under *Ch. setosum* Wint., to the effect that *Ch. setosum* Wint. is the same as *Ch. indicum* Zopf, but not the same as *Ch. indicum* Cda., is not easily understood, since Zopf in Nova Acta (p. 279) simply copied Corda's description of *Ch. indicum*, and made no statements which seem in any way at variance with Corda's original description.

On the one hand this species may be confused with *Ch. elatum*, from which it differs in the small size of its perithecium, the spreading or reflexed branches of the terminal hairs, and by its spores which have much smaller dimensions. On the other hand it may be confused with *Ch. funicolum*, especially when only the mature stage is studied. In its younger condition *Ch. indicum* is covered throughout with straight, spine-like hairs, the lateral ones only of which are visible at maturity. Later terminal hairs appear with branches spreading or reflexed, and still later, hairs which branch by narrow angles and which grow up among the branches of those already formed. In this way a dense head is formed consisting of innumerable branches, and the identity of the hairs is more or less concealed. The plant finally has a greenish-gray and powdery appearance similar to that of *Ch. funicolum* Cke., due in part to the large number of refractive hair tips and also to the clusters of crystals on the ultimate branches.

15. CHAETOMIUM ELATUM Kunze & Schmidt, Deutsch. Schwäm. 3. 1818; Fries, Syst. Myc. 3: 253. 1829

Chaetomium atrum Link; Linnaeus, Spec. Plant. Ed. 5, 1: 40. 1824.
Chaetomium atrum, var. *distinctum* Roumeguère, Rev. Myc. 8: 198. 1886. Not *Chaetomium atrum*, var. *Therryana* Roumeguère & Patouillard, Rev. Myc. 5: 29. 1883.
Chaetomium comatum (Tode) Fries, Syst. Myc. 3: 253. 1829. Not *Chaetomium comatum*, var. *helicotrichum* Saccardo, Michelia 1: 222. 1878.
Chaetomium comatum, var. *ligni* Roumeguère, Fung. Gall. LXIV, 6309.
Chaetomium Fieberi Corda, f. *chartarum* Roumeguère, Fung. Gall. LIX, 5827. 1891.

Chaetomium Fieberi Fuckel, Symb. Myc. 90. 1869. Not *Ch. Fieberi* Corda.

Chaetomium glabrescens Ellis & Everhart, Proc. Acad. Nat. Sci. Phil. 1893: 130. 1893.

Chaetomium graminicolum Fuckel, Fung. Rhen. VII, 647. 1863.

Chaetomium graminis Rabenhorst, Bot. Zeit. 34: 569. 1851.

Chaetomium lageniforme Corda, Icones 1: 24. *pl. 7, f. 293A.* 1837.

Chaetomium Libertii Roumeguère & Patouillard, Rev. Myc. 5: 15. *pl. 35, f. 2.* 1883; Fung. Gall. XXIV, 2376.

Chaetomium pannosum Wallroth, Flora Crypt. German. 2: 267. 1833.

Chaetomium velutinum Ellis & Everhart, Jour. Myc. 1: 90. 1885.

Conoplea atra Sprengel, Syst. 4: 554.

Conoplea atra Persoon, Syn. Fung. 1: 235. 1801.

Sphaeria comata Tode, Fung. Mecklenb. 2: 15. 1791.

PLATE 6, FIGS. 1–5

Black. Perithecia large, ovate, 435 × 391 μ (418–500 × 334–451), seated on a subiculum of dark olive-brown to black rhizoids which most frequently hold the perithecia in place through old age. Lateral hairs numerous, long, slender, graceful, unbranched, near the base dark olive-brown to black, coarsely roughened and about 5 μ in thickness, gradually tapering and fading to slender, pale to hyaline smooth tips which are obscurely septate. Terminal hairs extremely coarse, conspicuously roughened throughout with irregular pyramidal projections and blunt spines, once or twice dichotomously branched with the branches widely spreading and often reflexed and once or twice irregularly forked by an acute angle, at base black and about 9.5 μ in thickness, tapering and fading to slender, hyaline tips. Asci broadly and irregularly club-shaped, 8-spored, 64–75 × 17 μ, pars sporif. 34 μ. Spores hyaline to light olive when young, when mature dark, rich, olive-brown, lemon-shaped, apiculate at both ends, 12.8 × 8.7 μ (12–13 × 8.4–9.5), when seen edgewise, compressed, 7.4 μ broad.

EXSICCATI.—Brit. Fung. I, 49; Deutsch. Schwäm. 184; Erb. Crit. Ital. XVII and XVIII, 877; Fung. Aust. X, 989; Fung. Bavar. X, 927; Fung. Brit. I, 100, and III, 290; Fung. Carol. III, 66; Fung. Columb. VII, 621, and XI, 1034; Fung. Europ. VI, 529, XII, 1147, and XXVI, 2527; Fung. Fenn. IX, 820, and

X, 980; Fung. Gall. I, 66, and XV, 1428; Fung. Rhen. VII, 646; Fung. Rossiae II, 83; Fung. Sax. XVII, 834; Herb. Crypt. Belg. I, 83; Herb. Myc. I, 58; Klotzsch. Herb. Viv. Myc. XI, 1032; Myc. March 343, 4534, 4751; Myc. Univ. VIII, 758; N. A. F. VI, 560; Pl. Crypt. de Fr. Set. I, V, 237; Rehm. Asc. 247b; Schweiz. Krypt. XI, 526; Sub *Ch. atrum* Link: Fung. Gall. IV, 325; M. & N. Stirp. XV, 1483; Pl. Crypt. de Fr. Set. III, II, 86. Sub *Ch. atrum* Link, var. *distinctum* Roum.: Fung. Gall. XXXIX, 3883. Sub *Ch. atrum* Link, var. *Therryana* Roum. et Pat.: Fung. Gall. XXV, 2496. Sub *Ch. comatum* (Tode) Fr.: Erb. Crit. Ital. Series II, XVI, and XVII, 834; Fung. Gall. X, 975; Jaap, Fung. 372; Krypt. Vind. 1814; Misc. rar. (Vestergren) LVII–LVIII, 1420; Myc. Ital. IX, 841; Myc. March. 4016; Myc. Venet. VII, 636. Sub *Ch. comatum* (Tode) Fr., *var. ligni* Roum.: Fung. Gall. 64, 6309. Sub *Ch. Fieberi* Cda., var. *chartarum* Roum.: Fung. Gall. LIX, 5827. Sub *Ch. graminicolum* Fckl.: Fung. Rhen., VII, 647. Sub *Ch. graminis* Rabh.: Klotzsch. Herb. Viv. Myc. XVI, 1555. Sub *Ch. lageniforme* Cda.: Herb. Myc., Edit. Nova, VI, 521. Sub *Ch. Libertii* Roum. et Pat.: Fung. Gall. XXIV, 2376. Sub *Ch. murorum* Cda.: Fung. Europ. Series II, Edit. nova, III, 234. Sub *Ch. pannosum* Wallr.: Fung. Europ. Series II, XXI, 2025; Fung. Gall. I, 61; Herb. Myc., Edit. Nova., VIII, 748; Klotzsch. Herb. Viv. Myc. XVI, 1556; Myc. March. 1548, 4752; Myc. Ital. XV, 1475.

This is a very common and widely distributed species, having appeared on substrata of very varied character such as old rope, straw, paper, barrel hoops, old brooms, and on the dung of different animals. The writer has found this species on such materials from many localities in New England, and from the Carolinas, Maryland, California, Illinois, New Jersey, and Pennsylvania; also from Switzerland, Germany, and the Galapagos (Chivers No. 15). The species has also been reported by many other authors from different localities in North America, from England, Scotland, Russia, and from many places in Europe.

There is no species of *Chaetomium*, with the possible exception of *Ch. globosum* Kze. which has received so much attention as *Ch. elatum*, and while the characteristics described by Kunze

and figured by Greville seem to be very clear, the form has been re-described under many different names and confused many times with other species.

In 1818 Kunze gave the name *Ch. elatum* to specimens which were collected in the spring at Halle, Germany, on dead leaves of *Typha* and *Sparganium*, and which also occurred commonly on dried stems and leaves of the Aroidaceae and Gramineae. He called attention to the simple, unbranched hairs of the perithecium near the base, and the very long, rigid, branched hairs above, and while he gave no measurements of spores, he described their shape as oviform or globose.

In 1826 Greville (**43**) published a diagnosis of Kunze's *Ch. elatum* accompanied by six figures, and while the description contains no more information than that of Kunze, the figures are instructive.

In 1824 H. F. Link (**54**) published a note included in a brief comment on the *Conopleae*, to the effect that *Conoplea atra* Persoon is *Chaetomium atrum*, and in 1853 Desmazières (**26**) made the following statement: "According to specimens which we have received from M. Persoon, his *Conoplea atra* is surely a *Chaetomium* and not the *Myxotrichum chartarum* Fries [**38**, p. 349] thought it to be." It should here be stated that in connection with his specimens Desmazières listed *Conoplea atra* Persoon as a synonym under *Ch. atrum* Link, and indicated that he had verified the synonymy. The very generous specimens of *Ch. atrum*, which were distributed by Desmazières, have been examined and found to be typical in every way of *Ch. elatum* Kze. It may be seen, therefore, that *Conoplea atra* Persoon is identical with *Ch. atrum* (Persoon) Link, and with *Ch. elatum* Kze.

In 1829 Fries (**38**) gave to the *Sphaeria comata* of Tode (**103**) the new name *Ch. comatum*, and the use of this and of Kunze's older name, *Ch. elatum*, has varied with later authors. In many cases the former has been arranged as a synonym under the latter, but Saccardo (**79**, p. 221) and several other authors prefer the use of *Ch. comatum* (Tode) Fr., with *Ch. elatum* listed as a synonym thereto. While Fries published no figures there seems to be no doubt that his form is identical with Kunze's species, and since adequate description and figures of this plant under the name

Ch. elatum were published by Kunze and Greville previous to the time Fries introduced the name *comatum* into the genus, and so far as the present writer is aware, no figures under the name *Ch. comatum* have ever appeared, it seems best to arrange *Ch. comatum* as a synonym under *Ch. elatum* Kze.

In 1833 this plant was re-described by Wallroth under the name *Ch. pannosum*. Zopf (**113**) in 1881 listed and figured Wallroth's species, and stated in connection with his description of *Ch. elatum* Kze. that the two forms differed on account of the fact that in the former the mycelium was red brown, while in *Ch. elatum* it was a golden color. His figures of *Ch. pannosum*, however, show characteristics identical with those of *Ch. elatum*, and even though the present writer, in all cultures of this plant, has found the mycelium varying only from white to yellow and greenish-yellow, he is inclined to disagree with Zopf regarding the separation of these forms into two species, and rather to list *Ch. pannosum* as a synonym under *Ch. elatum*. The writer is led to question if color-producing bacteria which so easily contaminate cultures, or some change such as peculiar fading induced by the environment or substratum, would not account for the appearance which Zopf found in his cultures.

The species was re-described and figured by Corda in 1837 as *Ch. lageniforme*, and again by Rabenhorst in 1851 as *Ch. graminis*. While Rabenhorst speaks of the hairs of his species as somewhat simple and not intertwined, it has been found from a study of authentic exsiccati specimens, in Klotzsch. Herb. Myc. No. 1555, that they are no less branched nor intertwined than in *Ch. elatum*.

Fuckel (**40**) listed this plant in 1861 as *Ch. graminicola* and distributed specimens under that name in Fungi Rhenani No. 647. It should be stated here that Fuckel used Rabenhorst's name in connection with his specimens. It has been impossible to find any reason for the use of the name *graminicola*. The writer is led to the conclusion that *graminis* is the basis for this usage and that Fuckel has mistaken this for *graminicola*. The form to which Fuckel in 1869 called attention in the Symbolae Mycologicae (p. 90) under the name *Ch. Fieberi* is without question identical with *Ch. elatum*.

In 1883 Roumeguère and Patouillard redescribed the species as *Ch. Libertii*. The writer has examined authentic exsiccati specimens of this form in Fung. Gall. No. 2376, and it is not clear to him why in their diagnosis, the authors compared and contrasted it with *Ch. crispatum*, since it does not bear the slightest resemblance to that species.

In 1885 Ellis gave the name *Ch. velutinum* to specimens which were collected by Carpenter on a damp maple log, but in North American Pyrenomycetes (**32**, p. 124) the same author lists *Ch. velutinum* as a synonym under *Ch. pannosum*. According to the arrangement used by the present writer Ellis's name must be listed as a synonym to *Ch. elatum*.

In 1886 Roumeguère applied the name *Ch. atrum* Link, var. *distinctum*, to this species which he found growing isolated and arranged in parallel lines on poplar wood. While the preparation which could be obtained from Fung. Gall. No. 3883 was broken and somewhat scanty, it was possible to identify and study the spores and fragments of the branched hairs. The characteristics of these structures were found to vary in no way from those of *Ch. atrum* Link, and therefore from *Ch. elatum* Kze. That perithecia should be scattered or that they should appear arranged in lines along the substratum would seem to be conditions which could hardly warrant the separating of a variety from the type form, since such characteristics are likely to appear in any species, especially when the substratum is more or less furrowed as it is in the case of stems.

In 1891 Roumeguère distributed specimens of the same plant in Fung. Gall. No. 5827, under the name *Ch. Fieberi* Cda., f. *chartarum*. No description was published at that time, however, and so far as can be learned, no mention or diagnosis has since been made. The present writer has examined authentic specimens and has found them to be characteristic of *Ch. elatum* Kze. in all details. Two years later, in 1893, the same author used the name *Ch. comatum* (Tode) Fr., var. *ligni*, in Fung. Gall. No. 6309, for plants which he found on wood. Here again no description is to be found with the specimens and no subsequent mention of them has appeared. It does not seem advisable to retain this name and set apart a variety from the type form simply on

account of the fact that it was found on wood, especially since a study of the authentic exsiccati specimens shows all structures to be typical of *Ch. comatum* (Tode) Fr. which, as we have seen, is synonymous with *Ch. elatum* Kze.

Finally Kunze's species was redescribed by Ellis in 1893 under the name *Ch. glabrescens*. It has been possible to examine type specimens of Ellis's species which are now in the possession of Dr. Farlow at Cambridge, and while the mounts contain for the most part rather fragmentary remains of perithecia, and while the hairs in most cases are broken below the point of origin of the first branches, still in other cases clusters of terminal hairs show characteristics identical with those of *Ch. elatum* Kze. The spores also are typical of Kunze's species both in shape and size.

All exsiccati mentioned above have been carefully examined and with two exceptions have been found to be typical of *Ch. elatum*. However, only plants of *Chaetomidium fimeti* (Fkl.) Zopf could be obtained from exsiccati specimens of *Ch. atrum* Link in Fung. Gall. IV, 325, and of *Ch. atrum* Link, var. *Therryana* Roum. et Pat. in Fung. Gall. XXV, 2496. In the specimens of *Ch. pannosum* Wallr. in Myc. Ital. XV, 1475, perithecia of *Ch. murorum* Cda. appeared in considerable numbers.

The following exsiccati specimens also consist wholly or in part of *Ch. elatum* Kze.: *Ch. chartarum* Ehr. in N. A. F. No. 1541; *Ch. Fieberi* Cda. in Fung. Gall. No. 6409, Herb. Myc. No. 165, and Myc. Ital. No. 1288; *Ch. Fieberi* Cda., var. *chartarum* Roum. in Fung. Gall. No. 5827; *Ch. Kunzeanum* Zopf in Myc. March. No. 3246; *Ch. lanosum* P. in Fung. Gall. No. 4437; *Ch. murorum* Cda. in Fung. Europ., Series II, Edit. nova, III, 234; *Ch. olivaceum* Cke. and Ellis in Myc. Univ. No. 1942 and in Fung. Columb. No. 512.

No other species with which this should be confused have come to the attention of the writer with the exception of *Ch. indicum* Cda. and *Ch. funicolum* Cke., from both of which it differs in its large size, coarse appearance, and in the greater size of its spores.

16. CHAETOMIUM SPINOSUM Chivers, Proc. Am. Acad. 48: 86. 1912

PLATE 10, FIGS. 1–7

Golden-yellow. Perithecia of medium size, ovate, obovate or subglobose, 290 × 224 μ (273–318 × 206–262), frequently provided with a single cirrhus and rhizoids. Lateral hairs numerous, straight, rigid, spine-like, roughened by minute spines or projections which are irregular in shape, at base black or nearly so and about 7.5 μ in thickness, fading to dark olive-brown, terminating in a yellow or colorless, collapsed, hypha-like tip, obscurely septate in upper part. Terminal hairs straight, rigid, acute, at first of the same nature as the lateral hairs, later producing elaborate systems of branches which at first consist of club-shaped out-growths from the main shaft directed either at right angles with it, or backward from it. Later the primary branches become branched until an intricate system is formed. Branches light yellow to colorless, covered with delicate spines. Asci very narrowly club-shaped, 41 × 7.5 μ, pars sporif. 22 μ. Spores when young filled with granules and globules, greenish, refractive, when mature pale olive, egg-shaped, 5.9 × 3.9 μ (5.6–6.4 × 3.2–4).

Growing in cultures of dung from Buenos Ayres, R. Thaxter (Chivers No. 7).

This is apparently a rare species having appeared but once. The egg-shaped spores and the branched, terminal hairs are peculiar to the species. From the dark, stiff, spine-like shafts of the terminal hairs arise slender, delicate, irregularly swollen and constricted outgrowths, from which secondary branches arise which elongate and precede the cirrhus of spores as it forms. In this way a support is formed for the spore mass.

17. CHAETOMIUM AMPULLARE Chivers, Proc. Am. Acad. 48: 86. 1912

PLATE 10, FIGS. 8–12

Ochre. Perithecia rather large, extremely elongated, flask-shaped, 489 × 147 μ (456–532 × 137–167), producing at maturity a copious, black mass of spores and olive-yellow rhizoids. Lateral hairs comparatively few, long, slender, graceful, straight or nearly so, insensibly tapering, at base dark olive-brown, smooth or very minutely roughened and about 7.5 μ in thickness, above bright yellow, terminating in rather long, colorless, refractive, thin and more or less collapsed tips. Terminal hairs smooth, very long,

graceful, insensibly tapering, straight for a long distance above the base, distinctly and regularly septate, at base about 7.5 μ in thickness, from base to apex successively golden-brown, golden-yellow, pale yellow, hyaline, terminating in colorless, elongated, more or less collapsed tips, producing in the upper portions branches which are frequently septate and only slightly colored at base, hyaline and delicate above, and which in turn produce branches of like nature. Asci club-shaped, 8-spored, 45 $\times$ 9.7 μ, pars sporif. 23 μ. Spores bright olive-yellow, umbonate at either end, lemon-shaped, 8.1–8.9 $\times$ 6.4 μ.

On culture of sail cloth from Lowell, Massachusetts (Chivers No. 4). On dung from North Carolina (R. Thaxter).

This species is clearly characterized by the very much elongated bottle-shaped perithecium, and by the terminal hairs which are drawn out into long, hyaline, tangling, easily collapsible threads, the branches of which may be very easily overlooked except with higher magnifications.

18. CHAETOMIUM CUNICULORUM Fuckel, Symb. Myc. 89. 1869

Brownish-black. Perithecia spherical, ovate or egg-shaped, 370 μ. Terminal hairs few, dark brown at base, lightly colored at tips, twice as long as the perithecium, straight below, stiff, septate, 5–7 μ in thickness, seldom branching at the base, more or less encrusted with calcium oxalate, thickly entangled, forming a compact mass about the ostiole, some remaining simple, others branching dichotomously at their summits and anastomosing with each other by their free ends. Lateral hairs straight, rigid, tapering, unbranched. Asci club-shaped, 8-spored. Spores dark olive-brown, elliptical or spindle-shaped, barely apiculate at the ends, 10–12 $\times$ 7–9 μ.

EXSICCATI.—Fung. Rhenan. 1961.

Type locality: Freinweinheim, Germany; on rabbit dung. Reported also by Bainier as occurring very commonly on dung of rabbit.

In spite of repeated attempts it has been impossible to obtain a satisfactory mount from the type material of *Ch. cuniculorum* Fckl. from the set of Fungi Rhenani at Harvard University. The specimens consist of two rabbit pellets, exposed to the leaves of the book. These pellets are thickly covered with perithecia of Sordaria, but at best only fragments of perithecia of *Chaetomium* could be obtained. In several cases many bases of hairs could

be distinguished which were very dark to black below, yellow and finally hyaline and refractive above, clearly septate, and irregularly branched. These hairs were studied with extreme care with the hope that anastomosing branchlets might be found, but none could be seen.

The species was first described by Fuckel, in the Symbolae Mycologicae, in 1869, and again by Zopf in his monograph in Nova Acta in 1881, and was finally redescribed and figured by Bainier in his monograph in 1910. Since the writer has never found this form and the available type specimens have not been entirely satisfactory, he has been obliged to rely on those mentioned above for his information. Zopf in comparing and contrasting this species with "*Ch. Kunzeanum*" has stated that the two resemble each other in respect to the dense mass of terminal hairs, but differ in respect to the shape and size of the spores. Bainier has stated that the perithecia are pure white during their earlier stages, and that the terminal hairs may be divided into two groups, those which are 5.6 μ in diameter, long and rigid, and those only 1 μ in diameter and only half as long as the first type. He described the spores as dark bluish-gray or greenish.

19. CHAETOMIUM SPHAERALE Chivers, Proc. Am. Acad. 48: 84. 1912

PLATE 11, FIGS. 18–23

Grayish-yellow, olive-yellow, with age golden-yellow. Perithecia rather large, globose or subglobose, evenly rounded at base, distinctly narrowed above, 312 × 276 μ (300–329 × 262–300), frequently provided with short, black cirrhi, without rhizoids. Lateral hairs numerous, graceful, slender, regularly and distinctly septate, olive at base, fading toward the tip to golden-yellow then pale yellow, terminating in a colorless, easily collapsible tip, some rather straight and long, 1–2 branched, at base about 3.7 μ in thickness, others wavy, rather short, unbranched, at base about 2.8 μ in thickness. Terminal hairs long, slender, graceful, with color as in lateral hairs, smooth, irregularly waved or loosely and irregularly spirally convolute, 1–5 branched, at base distinctly septate, at apex obscurely septate or continuous. Asci club-shaped, 8-spored, 48 × 13 μ, pars sporif. 26 μ. Spores when young filled with refractive greenish hyaline globules, when mature dark olive-brown, lemon-shaped to globose, apiculate or umbonate at both ends, 7.3–8.1 × 6.4 μ.

A rare species having appeared only once in a culture of caterpillars from Reading, Massachusetts (Chivers No. 28).

The perithecium, globose below and conspicuously narrowing above, is peculiar to this species. The slender delicate hairs and the entire absence of differentiated rhizoids are also significant characteristics.

20. CHAETOMIUM GLOBOSUM Kunze, Myc. Hefte 1: 15, 16. *f. 9a–d.* 1817

Chaetomium affine Corda, Icones 4: 37. *pl. 8, f. 101.* 1840.

Chaetomium amphitrichum Corda, Icones 4: 37. *pl. 8, f. 103.* 1840.

Chaetomium Araliae Corda, Icones 4: 37. *pl. 8, f. 102.* 1840.

Chaetomium chartarum Ehrenberg, Sylv. Myc. Berol. 15, 27. 1818.

Chaetomium cymatotrichum Cooke, Grevillea 12: 21. 1883.

Chaetomium Elasticae Koorders, Verhandd. d. K. Akad. v. Wetenschappen te Amsterdam (Tweede Sectie) 13^4: 185. *f. 16.* 1907.

Chaetomium Fieberi Corda, Icones 1: 24. *pl. 7, f. 293c.* 1837.

Chaetomium Fieberi Corda, var. *chlorina* Saccardo, Myc. Venet. X, 906, 1876; Michelia 1: 27. 1877.

Chaetomium Fieberi Corda, *** *Saccardianum* Bommer & Rousseau, Misc. Myc. 1: 17. 1884. Not *Chaetomium Fieberi* Fuckel.

Chaetomium Kunzeanum Zopf, Nova Acta Acad. Leop.-Carol. 42: 278. *pl. 15.* 1881.

Chaetomium Kunzeanum, var. *chlorina* "Mich." Bull. Soc. Myc. France 25: 202. *pl. 13, f. 1–4.* 1910.

Chaetomium Kunzeanum, var. *fimicolum* Bommer & Rousseau, Bull. Soc. Roy. Bot. Belgique 23: 207. 1884.

Chaetomium lanosum Peck, Rep. New York State Mus. Nat. Hist. 28: 64. 1876.

Chaetomium macrosporum Saccardo & Penzig, Michelia 2: 591. 1882.

Chaetomium megalocarpum Bainier, Bull. Soc. Myc. France 25: 202. *pl. 16, f. 1–4.* 1910.

Chaetomium olivaceum Cooke & Ellis, Grevillea 6: 96. *pl. 100, f. 38.* 1878.

Chaetomium olivaceum, var. *chartarum* Ellis & Everhart, N. A. Pyren. 125. 1892.

Chaetomium olivaceum, f. *chartarum* Roumeguère, Rev. Myc. 11: 130. 1889.

Chaetomium oospora Beauverie, Ann. Univ. Lyon, Nouv. Sér. I. **3**: 201–218. 1900.

Chaetomium orientale Cooke, Grevillea **5**: 103. *pl. 86, f. 11.* 1877.

Chaetomium setosum, Bainier, Bull. Soc. Myc. France **25**: 209. *pl. 18, f. 3–7.* 1910.

Chaetomium spirilliferum Bainier, *l. c.* **25**: 207. *pl. 16, f. 1–4.* 1910.

Chaetomium undulatum Bainier, *l. c.* **25**: 208. *pl. 16, f. 4–7.* 1910.

PLATE 10, FIGS. 13–16; PLATE 15, FIGS. 9–14

Gray, green, chocolate brown, or olive-brown. Perithecia rather large, variable in shape, somewhat elongated or subglobose with a bluntly pointed base, when young yellow, translucent, allowing the cellular structure of the wall to appear, when mature opaque, black, 225–250 μ (205–320 × 205–280), frequently producing short, black cirrhi, and seated on a thick mass of dark olive to black rhizoids. Lateral hairs numerous, slender, graceful, plainly or obscurely and remotely septate, minutely roughened with spines, at base rather dark olive-brown with maximum thickness of about 3.7 μ, light olive or hyaline at tip, straight or only slightly flexed, or more slender and undulate or even kinked. Terminal hairs extremely numerous, and intricately interwoven forming a neat, rather compact head, or in age spreading and drooping even to the substratum, or to the hairs of neighboring perithecia, slender, graceful, without septa, minutely roughened with spines throughout, about 3.5 μ in thickness and dark at base, dark olive through greater part of length, with tapering and pale yellow to hyaline tips, wavy or undulate or kinked. Asci irregularly club-shaped, 8-spored, 64 × 13 μ, pars sporif. 37 μ. Spores when young colorless, filled with several large, refractive globules, when mature dark, rich, olive-brown, varying in shape from broadly ovate or subglobose to lemon-shaped, or fusiform, with ends apiculate or umbonate or nearly rounded, varying also in size, 10.5 × 8.5 μ (9.5–13 × 6.3–9.5), when seen edgewise, frequently compressed, 7.3 μ broad.

EXSICCATI.—Fung. Gall. XLV, 4438; Klotzsch Herb. Viv. Myc. X, 959. Sub. *Ch. chartarum* Ehrb.: Fung. Austro-Americani, 193; Fung. Brit. IV, 328; Fung. Gall. XI, 1090; Micro.-

Fung. Brit. 475; N. A. F. 2nd Series, 1541. Sub *Ch. Fieberi* Cda.: Fung. Gall. LXV, 6409; Herb. Myc., Edit. Nova, II, 165; Myc. Ital. XIII, 1288. Sub *Ch. Fieberi* Cda., var. *chartarum* Roum.: Fung. Gall. LIX, 5827. Sub *Ch. Fieberi* Cda., f. *lignicola chlorina* Sacc.: Myc. Venet. X, 906. Sub *Ch. Kunzeanum* Zopf: Fung. Gall. XLV, 4436; Fung. Longob. I, 31; Myc. March. 3246. Sub *Ch. lanosum* Peck: Fung. Gall. XLV, 4437. Sub *Ch. olivaceum* C. & E.: Fung. Columb. VI, 512; Myc. Univ. XX, 1942; N. A. F. I, 56. Sub *Ch. olivaceum* C. & E., var. *chartarum* Roum.: Fung. Gall. L. 4930.

A very common species of *Chaetomium*, having been found on substrata of very varied nature in nearly all countries (Chivers No. 26). Type locality: Leipzig; on dead stalks and leaves of various plants.

Probably no species of *Chaetomium* is of so common occurrence as *Ch. globosum*, and certainly no other has been given so much attention both from a systematic and a morphological point of view. It was first described and figured by Kunze as a type form of his new genus, having appeared often in company with *Sphaeria doliolum* on dead stalks and leaves of various plants, in damp wet places in Leipzig, during the spring and autumn. It was described by that author as a globular fungus, a fourth of a line in size, black when in fresh condition, and entirely covered with hairs. His four very simple figures illustrate: a comparatively young plant; a later stage when under the influence of moisture a punctiform opening appears at the crown of the fungus; a group of somewhat spherical transparent spores which were mixed with a gelatinous mass; and a cross-section through the body of the closed fungus.

While, as may be seen, Kunze's description is of a general and indefinite nature, and his figures are quite inadequate for a sure identification of the form with which he worked, it seems reasonable to conclude that it is the same which Zopf described and figured in his monograph as *Ch. Kunzeanum*. For reasons not stated, but presumably on account of the fact that the term *globosum* might be applied to any one of several species, Zopf believed Kunze's form to be poorly named, and considered the alternative of retaining the old name though unsatisfactory or of

giving an entirely new name, in which latter case he would be disregarding a proper respect of the original author. He finally named Kunze's species *Ch. Kunzeanum* in honor of the founder of the genus. It would hardly seem that this change was justified, and in the present monograph, therefore, Zopf's *Ch. Kunzeanum* appears as a synonym under *Ch. globosum* Kze.

In 1818 Ehrenberg added the name *Ch. chartarum*, the description of which is indefinite and without figures. No mention is made of spores and the statements regarding the hairs and perithecia are of a most general nature. A description and figures of this species were published by Corda (23) in 1840, and there seems to be little doubt that the plant in question is identical with *Ch. globosum* of Kze. Since Ehrenberg's time certain writers have retained the name *Ch. chartarum*, but as it is reasonably certain that Ehrenberg's species is identical with that of Kunze, it seems most reasonable to list *Ch. chartarum* as a synonym under *Ch. globosum* Kze.

In 1837 and 1840, in the Icones Fungorum, Corda described and figured four new species of *Chaetomium: Ch. Fieberi*, *Ch. affine*, *Ch. amphitrichum*, and *Ch. Araliae*. The simple, wavy, undivided hairs and the characteristic spores as described and figured would indicate that *Ch. Fieberi* is beyond a doubt identical with *Ch. globosum* Kze. The recognition of the three remaining species is not so easy, however, but it seems entirely possible that all these are forms of the same plant and should be listed under *Ch. globosum* Kze. Corda himself stated that *Ch. affine* is similar to *Ch. globosum* but was to be distinguished from it by the inverted egg-shaped spores. Zopf listed this in his monograph as a synonym to his *Ch. Kunzeanum*. Corda stated that *Ch. Araliae* and *Ch. amphitrichum* are distinguished from all other species of the genus described up to that time by the light color of their spores, but in his diagnoses these spores are given characteristics not unlike those of other species. In two of the three diagnoses under consideration he failed to give the sizes of spores, a fact which makes a sure determination more difficult. If his figures and descriptions are studied with care it will be found that, with the exception of the egg-shaped spores of *Ch. affine*, and slight differences in the shape of the hairs in the general figures of the three

species, the forms are very similar, and while it is singular that he should call these species new unless he felt satisfied that they possessed sufficient distinguishing characteristics, especially since he had already named *Ch. Fieberi*, which has all the characteristics of *Ch. globosum*, still it does not seem unreasonable to the present writer to place these forms as synonyms under *Ch. globosum* Kze., on the ground that Corda was dealing with different stages of the same plant.

In 1876 Dr. Peck redescribed Kunze's species under the name *Ch. lanosum*. Mounts of original specimens which were received from Dr. Peck show the perithecia and spores typical in all their characteristics of the younger stages of *Ch. globosum* Kze. It may be well at this point to call attention to the fact that the *Ch. lanosum* Peck, in Roumeguère's Fung. Gall. No. 4437, is identical with the plant which Zopf described under the name *Chaetomidium fimeti* (Fckl.).

The writer can hardly agree that it is desirable to apply the name *Ch. Fieberi* Cda., f. *lignicola chlorina* to the plant which Dr. Saccardo found on moist wood, and which he described in 1876, for the form seems in every way to be typical of *Ch. globosum* Kze. If one examines young stages of Kunze's species one frequently finds hairs which are straight for a considerable portion of their length, then taking a somewhat hooked turn, beyond which they become wavy. The same hooked characteristic is mentioned by Saccardo in his original description, but it may be seen from an examination of original material received from Dr. Saccardo, and from authentic specimens in Myc. Venet. X, No. 906, that such is true not of the mature perithecia, where the hairs are like those of *Ch. globosum*, but in the young immature plants. As for the color, it may be said that it is typical of Kunze's species, and that the plant was growing on moist wood seems to be insufficient cause for setting it apart as a variety, especially since *Ch. globosum* will thrive on almost any substratum so long as it is moist.

In 1877 Dr. Cooke described *Ch. orientale*, mounted material of which has been placed at the disposal of the writer through the kindness of the Royal Botanic Gardens at Kew. An examination of that material shows, in spite of the fact that the perithecia are

rather fragmentary, characteristics which are those of *Ch. globosum*, namely, olive-colored perithecia, simple flexuous hairs, and globose spores with slightly apiculate ends. The figure accompanying Cooke's original description shows the same characteristics.

In 1878 Cooke and Ellis gave the name *Ch. olivaceum* to a form which they found on rotting stems of *Erigeron*. It was at first thought by the present writer that this name could be associated with a species which he has found frequently and which has apparently been recognized for the first time by Palliser (67) as distinct from *Ch. globosum* Kze. This does not seem to be true however, and from detailed study of the original description and an examination of mounts made from the type material, one is forced to conclude that *Ch. olivaceum* C. & E. is identical with *Ch. globosum* Kze. It should be stated that the plants in each of the specimens of type material in three different herbaria are past maturity. Dark, rich olive, umbonate spores, and larger, much more lightly colored, apiculate spores, are to be found in both *Ch. olivaceum* and *Ch. globosum*, the former type appearing more commonly in *Ch. olivaceum*, the latter in *Ch. globosum*. The hairs in Cooke and Ellis's material, while old and for the most part frayed out, are typical of Kunze's species.

As a result of careful study of type specimens of *Ch. macrosporum*, which was described by Saccardo and Penzig in 1882, and which has been received from Dr. Saccardo, it has been found that this species possesses characteristics sufficiently similar to those of *Ch. globosum* to warrant placing it as a synonym under that name. According to Saccardo's description the hairs of the perithecium are olivaceous and flexuous, but the spores measure 14–16 μ. The original material was set apart into two parcels; the one containing plants which prove to be typical of the young *Ch. globosum*, the other typical mature plants of the same species. The spores which belong to the mature perithecia do not have the size indicated by Saccardo, but measure, as for *Ch. globosum* Kze., 10.5–12.5 $\mu \times 9.5\,\mu$. There are, however, intermingled with these plants the perithecia and spores of *Ch. murorum* Cda. Here may lie an explanation for the error made by the original writers, for the spores of *Ch. murorum* correspond

exactly to the measurements recorded in the diagnosis, 14–16 μ $\times$ 7–8 μ. The presence of *Ch. murorum* Cda. may also explain the statement that the species is somewhat allied to *Ch. crispatum* Fckl., for the perithecia are old and the hairs are very dark, almost opaque, and except for the circinately coiled tips, have somewhat lost their true characteristics.

It becomes evident from a study of the original description of *Ch. cymatotrichum* made by Dr. Cooke in 1883, and from an examination of mounts of type material supplied by the Royal Botanic Gardens at Kew, that this is identical with *Ch. globosum* Kze.

The writer has recently received from Dr. Saccardo specimens of *Ch. Fieberi* Cda., subspecies *Saccardianum*, described by Bommer and Rousseau in 1884 (**78**), and which according to Saccardo (**84**, p. 86) is equivalent to *Ch. Saccardianum*. While the plants are not in the best of condition it has been possible to determine with a reasonable degree of certainty that this variety is identical with *Ch. globosum* Kze. It is stated in the original description that the perithecia finally collapse and become cup-shaped. This is true in nearly all of the perithecia examined. The terminal hairs have been worn away and the shiny, black perithecial walls have collapsed. It is also stated that the hairs bear rough spherical conidia. While it is not possible to determine the origin of these conidia which are scattered among the rhizoids and perithecial hairs, the writer has no hesitation in concluding that these are entirely foreign to the *Chaetomia*, and are the fruiting bodies most probably of a *Cunninghamella*. The small number of perithecia which could be found still clothed with hairs were typical in every way of *Ch. globosum* Kze.

In 1884 Bommer and Rousseau (**8**, p. 207) published a new variety to *Ch. Kunzeanum* Zopf under the name *fimicola*. These authors compared their variety with *Ch. chartarum*, *Ch. globosum*, and *Ch. Fieberi*, and while type material is not at hand, it would seem from their description that the variety could well be included under *Ch. globosum* Kze. Marchal (**55**), referring to this variety as forma *fimicola*, called attention to the fact that the spores, measuring 14 $\times$ 8.6 μ, were a little larger than in the species above mentioned and that this plant could not be

identified with them as Zopf had listed them in his monograph. The larger size of the spores, however, seems an insufficient reason for setting apart this variety, for in *Ch. Kunzeanum* Zopf, the spores are found to vary in size from 9 μ to 13 μ in length and from 8 μ to 9.5 μ in width.

An examination has been made of mounts from original material which was described in 1892 by Ellis as *Ch. olivaceum* C. & E., var. *chartarum*, and which had already been listed and distributed without description by Roumeguère, in Rev. Myc. 11: 130 and Fung. Gall. No. 4930, in 1889, as f. *chartarum*. The spores have been measured and found rather to correspond with the somewhat variable spores of *Ch. globosum* Kze. As to the fact that the color varied from nearly black to mouse color and even to greenish-yellow, it may be said that such variations may easily be found in one and the same culture, and may be attributed to a difference in age. It hardly seems advisable to set plants with such a variable and uncertain characteristic apart from the type species.

During the same year Beauverie published an account of his work with cultures of the conidial form which Saccardo (77) called *Oospora crustacea*. In the month of June Beauverie found perithecia in tube cultures of potato which dated from January, and which were very tightly closed with cotton and covered with caoutchouc, so that no communication between the media and the outside air was possible. The white carpet of conidial vegetation was found to be spotted with small dark green bodies which were recognized as *Chaetomium*, and to which the name *Ch. oospora* was given. At two different times the writer has found conditions similar to those to which Beauverie has called attention in connection with his work. Cultures which were supposed to have been pure and had apparently remained uncontaminated for a considerable period showed in both cases the organization of perithecia which have finally developed into plants typical of *Ch. globosum*. While the writer has never examined type material of Beauverie's form, he is led to believe from his own experience and from Beauverie's description, that *Ch. oospora* is identical with the above named species of Kunze.

While only the original description and figures of *Ch. Elasticae*

published by Koorders (49) in 1907, have been available for study, the writer has concluded that this plant should be included under *Ch. globosum* Kze. In fact at the end of his diagnosis Koorders has stated that undoubtedly his species is related to *Ch. Kunzeanum*, which, as Zopf stated, has a very wide distribution on various substrata.

Bainier in his "Monograph of *Chaetomium*" (3) has treated the varied forms of *Ch. globosum* Kze. as distinct species, and has listed and described them under the following names: *Ch. megalocarpum*, *Ch. setosum*, *Ch. spirilliferum*, and *Ch. undulatum*. It is the opinion of the present writer that these should not be separated from the type form, since they prove to be extremely variable when grown in cultures.

In addition to the above mentioned forms it is possible that *Ch. Douglasii*, described by Schweinitz in 1834, and *Ch. Fieberi* Cda., var. *macropoda*, described by Spegazzini in 1898, should be listed here, but type specimens of these are not available and the description in both cases is of such a general nature that it is hardly possible to determine the identity of these forms. They will be found listed, therefore, among the doubtful species.

The above is as complete an account of the synonymy concerned with this species as the writer is able to give, and it may be well to state here that he has arrived at the above conclusions only after long experience in cultivating the variable forms of the species which have been gathered from nearly all parts of the world, and only after a thorough study of exsiccati and type specimens so far as they have been available.

From an examination of the above exsiccati it has been found that in several the specimens contain plants which belong to other species and in some cases at least to other genera. In the following only *Ch. elatum* Kze. could be found: *Ch. chartarum* Ehrb. in Micro.-Fung. Brit. No. 475; *Ch. Fieberi* Cda. in Fung. Gall. No. 6409; *Ch. Fieberi* Cda., var. *chartarum* Roum. in Fung. Gall. No. 5827; *Ch. Kunzeanum* Zopf in Myc. March. No. 3246, and *Ch. olivaceum* C. &. E. in Myc. Univ. No. 1942. The specimen under the name *Ch. chartarum* Ehrb. in Fung. Austro-Americani, No. 193 contains plants of *Ch. chartarum* (Berk) Winter, or *Ascotricha chartarum* according to the nomenclature

used in this paper. That under the same name in N. A. F. No. 1541 consists in part of *Ch. globosum* Kze., of *Ch. elatum* Kze., and of *Ch. cochliodes* Pall. No plants could be obtained from *Ch. chartarum* Ehrb. in Fung. Brit. No. 328, while from specimens under the same name in Fung. Gall. No. 1090 only *Stachybotrys lobulata* could be obtained. The specimen under the name *Ch. Fieberi* Cda. in Herb. Myc. No. 165 and Myc. Ital. No. 1288 is in part *Ch. globosum* Kze., and in part *Ch. elatum* Kze. Only *Ch. murorum* Cda. could be obtained from mounts of *Ch. Kunzeanum* Zopf, in Fung. Gall. No. 4436, while the specimens under the name *Ch. lanosum* Peck, in Fung. Gall. No. 4437 consist for the most part of *Chaetomidium fimeti* (Fckl.) Zopf, with a considerable number of perithecia of *Ch. elatum* Kze. intermingled. *Ch. olivaceum* C. & E. in Fung. Columb. No. 512 is found to consist partly of *Ch. globosum* Kze., of *Ch. elatum* Kze., and in part of *Chaetomidium fimeti* (Fckl.) Zopf.

21. CHAETOMIUM SPIRALE Zopf, Nova Acta Leop. Carol. Akad. 42: 275. *pl. 19, f. 21–26.* 1881

Chaetomium spirochaete Palliser, N. A. Flora 3: 61. 1910.

PLATE 12, FIGS. 5–8

Dark brown to black. Perithecia of medium size 150–300 μ, globose or ovate with a bluntly pointed base, seated on dark olive-yellow to brown rhizoids. Lateral hairs long, graceful, nearly straight or slightly flexed, very gradually tapering toward the tip, septate throughout, at base 3–5.5 μ in thickness, dark olive-brown, sometimes smooth but more frequently roughened by irregular hyaline bodies of varying size and shape, becoming smooth above and fading to a colorless or pale yellow tip. Terminal hairs sparsely septate, dark, rich olive-brown, roughened by minute spines and warts, slightly paler and somewhat less roughened near the tips, straight or only slightly bent below for 300–370 μ of their length, 4–6 μ in thickness at base, spirally coiled above with 6–14 turns. "Asci club-shaped, with a short stalk, pars sporif. 34–43 μ long." Spores lemon-shaped, slightly apiculate at either end or irregularly oval or spherical, dark rich olive-yellow to olive-brown, 9 × 7 μ (6–12 × 5.6–9), when seen edgewise, 5.5–7 μ broad.

The species above described is apparently not common, and has never appeared in any collections made by the writer. Type locality: near Berlin; on horse dung.

Through the kindness of the New York Botanical Garden the writer has been enabled to examine type specimens of *Ch. spirochaete* which were collected on cotton roots at Ames, Iowa, by L. H. Pammel, and which were named *Ch. spirochaete* by Palliser in her monograph of the genus. These seem to be identical with Zopf's species. The envelope containing the type specimens bears the name *Ch. bostrychodes* Zopf, for which this material had previously been mistaken. On a slip of paper within the envelope, however, was written in the form of a note: "Spores 10 × 7 μ, dark brown, too large for *bostrychodes* although same shape." The large size and dark color of the spores are characteristics which easily separate this form from *Ch. bostrychodes* Zopf, and identify it with *Ch. spirale* Zopf.

At first sight *Ch. spirale* Zopf might easily be confused with *Ch. bostrychodes* Zopf, which it so closely resembles so far as the hairs are concerned, but from which it differs markedly in spore characteristics. The characteristics of the asci are quoted from Zopf's original description.

22. CHAETOMIUM ATERRIMUM Ellis & Everhart; Palliser, N. A. Flora 3: 62. 1910

PLATE 12, FIGS. 1–4

Gray black to black. Perithecium of medium size, ovate or subglobose, 275 × 200 μ (190–300 × 160–230), seated on olive-yellow or olive-brown rhizoids. Lateral hairs numerous, long, slender, graceful, straight or slightly flexed, septate, gradually tapering, minutely roughened throughout or only near the base, below olive-yellow or dark olive-brown, 4–5 μ in thickness at base, above pale yellow or hyaline. Terminal hairs very rarely producing small abortive branches, opaque, olive-brown or black and roughened by minute spines throughout, irregularly septate, at base 5–6 μ in thickness, at tip 8–11 μ in thickness, below straight or slightly flexed, above coiling 10–18 times (usually about 15) in a long, close, regular, cylindrical spiral, 45–60 μ in diameter. Asci not visible. Spores olive-brown, lemon-shaped, slightly apiculate at either end, 7.5 × 6.5 μ (6.5–8 × 6.4), when seen edgewise, compressed, 4.8 μ broad.

This is an exceedingly rare form apparently known only from the type locality: Rockport, Kansas; on damaged wheat in a stack, 1891 (Bartholomew 448).

Through the kindness of the New York Botanical Garden it has been possible to examine type specimens of this interesting species. The large diameter of the terminal hairs and their exceedingly long and regular cylindrical spiral distinguish this from all other species.

23. CHAETOMIUM BOSTRYCHODES Zopf, Abh. Bot. Ver. Prov. Brandenburg **19**: 173; 1877. Nova Acta Acad. Leop.-Carol. **42**: 277. *pl. 20, f. 14–26.* 1881

Chaetomium caninum Ellis & Everhart, Jour. Myc. **4**: 79. 1888.

Chaetomium formosum Bainier, Bull. Soc. Myc. France **25**: 215. *pl. 20, f. 6–9.* 1910.

Chaetomium formosum, var. *neglectum* Bainier, *l. c.* **25**: 217. *pl. 18, f. 8.* 1910.

Chaetomium formosum, var. *ovatum*, Bainier *l. c.* **25**: 216. *pl. 20, f. 1–5.* 1910.

PLATE 13, FIGS. 1–11

Steel gray. Perithecia of medium size, extremely variable in shape, broadly ovate, globose or nearly cylindrical, generally with a bluntly pointed base, 340 × 220 μ (168–350 × 131–230), frequently provided with black, straight or re-curved cirrhi. Lateral hairs not numerous, encrusted, clearly and evenly septate, tapering, at base dark olive-brown and about 3.8 μ in thickness, at tips pale yellow or hyaline, frequently collapsed. Terminal hairs encrusted and roughened with spine-like projections throughout, at base straight or very slightly flexed, dark olive-brown to black and about 4 μ in thickness, slightly less colored at tips, always more or less spirally coiled but in this respect extremely varied. In the type either regularly coiled with seldom more than 5–7 convolutions which diminish almost imperceptibly in diameter toward the extremity, or irregularly coiled with two or three loose, irregular convolutions; in either case irregularly septate, producing along the convolutions one or more branches which in turn are septate and spirally coiled. Asci short, stout, club-shaped, 8-spored, 50 × 12 μ, pars sporif. 24 μ. Spores when young greenish, hyaline, with granular contents, when mature pale with olive-brown tint, oval to nearly spherical, clearly or obscurely apiculate, or rounded at both ends, frequently with an elliptical, refractive area abreast of each end, a characteristic observed only in this species, 7.4 × 6 μ (6.4–8 × 5.6–6.4), when seen edgewise, compressed, 4.8 μ broad.

EXSICCATI.—Fung. Europ. Edit. Nova, Series II, XXXIV, 3340; Myc. March. No. 43.

An extremely common species having appeared in cultures of dung of many animals from nearly all parts of New England, Florida, Chili, Venezuela, and China (Chivers No. 21). Reported also from many localities in middle western and western United States, and from England and Germany. Type locality,—Berlin and Göttingen; on decaying animal and vegetable substances (carcasses, potatoes, and rabbit dung).

In 1888 Ellis and Everhart (31) gave the name *Ch. caninum* to material found on dog dung in Louisiana. Later, however, the same authors (32) listed this name as a synonym under *Ch. bostrychodes* Zopf.

Ch. bostrychodes has proved to be a most variable species and before extensive cultures had been made the separation of the variable forms into distinct species seemed possible. A careful examination of plants grown under cultivation has been sufficient, however, to convince the writer that this should not be done, for there is no line which can be drawn between one variable form and another. While no material is available of *Ch. formosum*, *Ch. formosum*, var. *neglectum* and *Ch. formosum*, var. *ovatum*, all of which were described by Bainier in his monograph of *Chaetomium*, the writer is strongly of the opinion that they should be considered rather as variations of the type form.

The specimen in Fung. Europ. No. 3340 has been examined and found to be typical of *Ch. bostrychodes* Zopf.

24. CHAETOMIUM QUADRANGULATUM Chivers, Proc. Am. Acad. 48: 85. 1912

PLATE 14, FIGS. 1–8

Gray. Perithecia rather large and elongated, barrel-shaped, 403 × 294 μ (333–456 × 243–350), frequently provided with one or more very long cirrhi, producing a mass of dark olive rhizoids near base. Lateral hairs numerous, slender, straight, regularly and distinctly septate, at the base dark olive to black, minutely roughened and about 7.5 μ in thickness, in upper part pale yellow or hyaline, smooth. Terminal hairs of two types; (*a*) unbranched, minutely roughened, below dark olive-brown to black, straight, septate, above coiling in the form of a spiral with 2–6 convolutions, near tips light olive-yellow or colorless, sparsely septate; (*b*) showing tendency to twist in spiral fashion near the middle of their length, or curved or sometimes nearly straight throughout,

many with a single coil near the middle of their length, finely roughened throughout, below dark olive-brown to black, and about 7.5 μ in thickness, clearly septate to near tips which are hyaline (along the hairs of this nature several branches may be produced, the branches partaking of the nature of the hairs). Asci club-shaped, 8-spored, 39 × 9.7 μ, pars sporif. 21 μ. Spores when young greenish, hyaline with small refractive globules, when mature pale olive, when seen in face view four-sided and four-angled, either nearly square with equally rounded corners or with depressions in the four sides, in which latter case there are generally two acute angles at opposite ends which mark the length of the spore, while the angles at the sides are broad and obtuse, 7.3 × 6.3 μ (6.4–8 × 5.6–6.4), when seen edgewise ovate, 3–4 μ broad.

Cultivated on dung from Cambridge, Massachusetts (Chivers No. 29). Appearing also on dung from Chile and from Little Swan Island, Gulf of Mexico.

This species may be easily identified by its spores, which when seen in face view are four-sided and four-angled, but when seen in profile are oval. *Ch. quadrangulatum* and *Ch. trigonosporum* are the only species known to the writer which possess spores with angles, the former having spores clearly quadrangular, the latter clearly triangular.

25. CHAETOMIUM CAPRINUM Bainier, Bull. Soc. Myc. France 25: 223. *pl. 24.* 1910

PLATE 13, FIGS. 18–22

Steel gray. Perithecia large, tall, greatly elongated with greatest width just above the base, then narrowing with the upper portion cylindrical, 580 × 215 μ (400–580 × 200–228), seated on a subiculum of dark olive-brown to black rhizoids, with perithecium wall composed of cells greatly elongated in a plane parallel to the long axis of the perithecium, often provided with short, stout, black cirrhi. Lateral hairs rather numerous, tapering, septate, smooth or minutely roughened with spines, some uncutisularized, colorless and easily collapsible, others stouter, at base dark olive-brown and about 6.6 μ in thickness, fading and tapering gradually to a colorless, collapsed tip. Terminal hairs almost entirely obscured at maturity by the mass of spores, smooth or minutely roughened with spines, irregularly and remotely septate, at base straight or flexed, dark olive-brown, about 7.5 μ in thickness, fading toward tip, coiling above irregularly or in the form

of a spiral, producing here and there along their convolutions short branches which in turn are septate, tapering and irregularly coiled. Asci club-shaped, 8-spored, 50 × 10 μ, pars sporif. 24 μ. Spores when young greenish, hyaline, filled with granular contents, when mature pale with slight olive tint, ovate to globose, sometimes minutely apiculate at both ends, 6.6 × 5.1 μ (5.6–8.1 × 4.8–5.6), when seen edgewise, compressed, 4.5 μ broad.

On muskrat dung, Massachusetts; rat dung, Liberia, Herb. R. Thaxter; on dog dung, Connecticut (Chivers No. 20). Type locality: Paris(?); on goat and sheep dung.

It is possible that this species may be identical with *Ch. rostratum*, described by Spegazzini in 1899, but type specimens of his form are not available and it is impossible to decide with certainty from a study of the original description. Spegazzini's species has been listed, therefore, among the doubtful forms.

The species may be easily distinguished from *Ch. bostrychodes* Zopf, which it most nearly resembles, by the extreme length of the perithecium, a characteristic which has proved constant through cultures including many generations.

26. CHAETOMIUM COCHLIODES Palliser, N. A. Flora 3: 61. 1910

Chaetomium flexuosum Palliser, N. A. Flora 3: 61. 1910.

PLATE 15, FIGS. 1–8

Grayish-green, brilliant green, often losing color and becoming dark brown in dry herbarium material. Perithecia globose or subglobose with bluntly pointed base, 340 × 295 μ (318–360 × 273–310), forming black cirrhi in comparatively few cases only, producing a heavy mass of stout, dark olive-brown to black rhizoids which anchor the plants firmly to the substratum. Lateral hairs numerous, irregularly and sparsely septate, evenly roughened with extremely fine projections, some hairs rather stout, tapering, straight or evenly bent, at base about 5.3 μ in thickness and dark olive-brown to black, above faded yellow, at tips frequently hyaline, other hairs loosely and irregularly twisted through their entire length, still others straight for a long distance, then spirally twisted. Terminal hairs very numerous and finally interwoven forming a thick, massive, shaggy head, always of two types; (*a*) thick, stout, projecting beyond the dense portion of the head, then becoming spirally coiled with about three or four convolutions, dark olive-brown, almost black below, fading above to light yellow or becoming colorless, evenly roughened throughout and without visible septa, at base about 7.5 μ in

thickness; (*b*) slender, sometimes coiling in spirals, at other times irregularly twisted or undulate, medium olive to light yellow, lighter than those of type (*a*), about 2.5 μ in thickness at base. Asci irregularly club-shaped, 8-spored, 88 × 11 μ, pars sporif. 32 μ. Spores when young colorless, filled with refractive globules, when mature dark, rich olive-brown, lemon-shaped, apiculate at both ends, 9.5 × 7.2 μ (8.9–9.7 × 6.4–8.4), when seen edgewise, compressed, 6.4 μ broad.

EXSICCATI.—Sub *Ch. chartarum* Ehrb.: N. A. F. 1541 (in part).

On paper, straw, dung and leaves from many localities in New England. Also from middle western and southern United States, Java and Ceylon (Chivers No. 24). Type locality: Newfield, New Jersey; on paper (Ellis & Everhart in N. A. F. No. 1541 in part.)

Type specimens of the plant which Palliser in her monograph named *Ch. cochliodes* and which are to be found in North American Fungi, No. 1541, under the name *Ch. chartarum* Ehrb. have been examined by the writer. It has been discovered for the first time by Palliser that this is a separate species to be set apart from *Ch. globosum* Kze. It has been found frequently and, while its color as well as its general appearance at maturity may resemble *Ch. globosum* Kze., careful study in cultures and during its earlier development furnishes sufficient evidence that it is to be reckoned with as a distinct species.

It seems hardly advisable to consider *Ch. flexuosum*, which was described by Palliser (**65**) in 1910, a distinct species, but rather as a dilapidated condition of *Ch. cochliodes*. The type specimens of this plant have been found to be in extremely poor condition. Through the kindness of Professor Kauffman and Dr. F. J. Seaver, the writer has been provided with sufficient material of the original gathering to enable him to arrive at the conclusion that the plant is none other than *Ch. cochliodes*. Mounts of such material show, in the first place, that the plants are old and much weather-beaten. In most cases perithecia bear only rhizoidal hairs and stumps of the lateral and terminal hairs. One perithecium which was most perfect of all available shows its top to be covered with a large number of hairs which are stout, straight for a considerable distance, then loosely spirally coiled once or twice, at which point by far the largest number are

broken. There seems to be every reason to believe that the hairs, had not so many been broken away by disintegration, are sufficient in number and suitable in characteristics to make up a head typical of *Ch. cochliodes*. The spores are also typical of that species.

Ch. cochliodes Palliser may be confused, especially when fully developed, with *Ch. globosum* Kze. It may be most easily distinguished, in its earlier life history, when the terminal hairs show clearly two types; the one straight, stout below, spirally coiled above; the other much more slender, loosely spirally coiled, twisted or only wavy, and entangling the stouter hairs.

27. **Chaetomium angustum** sp. nov.

PLATE 16, FIGS. 6–12

Rich olive-green. Perithecia rather large, subglobose, with a bluntly pointed base, 304 × 266 μ (280–300 × 240–290), forming cirrhi in comparatively few cases, producing a dense mass of dark olive-brown to black, undulate rhizoids. Lateral hairs very numerous, obscurely and sparsely septate, either stout, tapering, dark, olive-brown to black at base and about 6.6 μ in thickness, fading above and becoming pale yellow, hyaline at tips, or slender, olive-yellow and flexed or irregularly, spirally twisted. Terminal hairs of three types: (*a*) straight, long, tapering, dark olive-brown to black at base, light yellow to hyaline at tips, minutely roughened throughout with spines, obscurely septate or continuous, at base about 6.7 μ in thickness; (*b*) slender, graceful, below straight or only slightly flexed and about 3.8 μ in thickness, in upper portions coiling spirally with about 5–7 convolutions which are comparatively small in diameter, minutely roughened throughout, sparingly septate or continuous, at base dark olive-brown, fading toward the tips; (*c*) stout, coarse, roughened throughout, sparingly and obscurely septate, below straight, very dark olive-brown, at base about 7.5 μ in thickness, above spirally coiled at first regularly coiled with 2–3 convolutions, often becoming irregular and retaining only a single coil near the middle of their length from which, frequently, one or two branches arise. Asci irregularly club-shaped, 8-spored, 50 × 14 μ, pars sporif. 23 μ. Spores when young greenish, hyaline, filled with irregular, refractive globules, when mature dark olive-brown, lemon-shaped, apiculate or umbonate, 10 × 8 μ (9.7–10.5 × 7.3–8.1).

On culture of bat dung from Porto Rico (Chivers No. 25).

This species may be confused with *Ch. cochliodes* Palliser, on

the one hand, and on the other hand with *Ch. globosum* Kze. From the former it differs in its straight terminal hairs, and in the fact that the terminal hairs never form a dense head. From the latter it differs also in its loose head of terminal hairs and in the fact that it possesses straight and stout, coarse, spirally coiled terminal hairs.

28. CHAETOMIUM TORULOSUM Bainier, Bull. Soc. Myc. France **25**: 224. *pl. 23*. 1910

PLATE 16, FIGS. 1–5

Golden-yellow. Perithecia of medium size, rather tall and elongated, vase-shaped, 355 × 170 μ (290–140 × 150–187), frequently provided with short, stout, blue-black cirrhi. Lateral hairs numerous, varying in length, delicate, smooth, generally slightly curved or bent, clearly and regularly septate, near base dark olive, about 3.7 μ in thickness, gradually fading above to yellow and ending in extremely slender, colorless, crumpled tips. Terminal hairs almost entirely concealed at maturity by the spore mass, long, slender, graceful, irregularly flexed, clearly and regularly septate to near the tips, conspicuously constricted at, and inflated between, the septa, dark olive-brown at base, about 3.8 μ in thickness, very gradually fading and tapering for a long distance, terminating in a long colorless, refractive thread. Asci irregularly club-shaped, 8-spored, 40 × 10 μ, pars sporif. 18 μ. Spores when young hyaline, filled with refractive globules, when mature very dark, rich olive-brown, lemon-shaped, apiculate, extremely variable in size, 9 × 7.6 μ (7.3–11.3 × 6.4–9), when seen edgewise, compressed, 4.5 μ broad.

In cultures of old paper, muskrat, rat and rabbit dung from various localities in New England (Chivers No. 5). Type locality: Paris(?).

This species may be easily distinguished from *Ch. ampullare*, which it most nearly resembles, by the fact that the perithecia are less elongated, the lateral hairs much more numerous and shorter, and the terminal hairs less rigid and conspicuously constricted at the septa.

SPECIES DUBIAE

Unfortunately it has been impossible to identify certain forms which have been described from time to time, on account of the fact that their characteristics are not given in sufficient detail

and no type material is at hand for examination. Since the present writer cannot speak with certainty regarding these. it has seemed best to list them as doubtful species.

In 1834 Schweinitz (91) described *Ch. Douglasii* as a very remarkable fungus allied to *Sphaeria comata*. In the herbarium of Curtis, now at Harvard University, there is a reference to this species and a very simple figure of it, but no specimen. Saccardo, in the Sylloge (p. 229), has listed this as a doubtful form. From a study of the very general description it seems possible that this may be identical with *Ch. globosum* of Kunze.

Ch. lanatum, which was described by Quelèt (70) in 1876 and to which reference has already been made, may possibly be identical with *Ch. globosum* Kze. Quelèt's description is of a very general nature, but his figures though simple show sinuous hairs like those of *Ch. globosum*, and spores similar in shape to those of the same species.

Little is known of the form which Spegazzini (94) found on dog dung in Italy, and which he described in 1878 as *Ch. stercoreum*. In the following year Saccardo (74) figured this and in 1894 Cavara reported it, but without further comment.

In 1881 Spegazzini (95) contributed a new form under the name *Ch. microsporum*. While no type specimens of this species are at hand it would seem that it might be identical with *Ch. globosum* Kze., with the exception that the spores, which measure 5–6.5 × 4–5 μ, are smaller than in Kunze's species.

It is impossible to determine from Karsten's (48) description, even though reasonably complete, the exact nature of the species which he described in 1888 under the name *Ch. humanum*, and so far as can be learned no author has since found or identified it.

The writer has little knowledge of the form which Starbäck (97) described in 1889 as *Ch. discolor*, and no specimens of the original material are at hand. It would seem, however, from a study of the description and diagrammatic figures, that with the exception of the smaller size of the spores the plant in question might be *Ch. globosum* Kze.

The original description and two general figures of *Ch. varium* described by Delacroix (25) in 1897 recall the characteristics of *Ch. globosum* Kze., but on the other hand figure 4 represents the

type of branching which is found in *Ch. elatum* Kze. The spores as figured are equally characteristic of either species. In a footnote Delacroix stated that the plant was allied to *Ch. lanosum* Peck, and to *Ch. comatum* (Tode) Fr., but such a condition could hardly be possible since those species differ so widely.

Reference has already been made to the possible identity of *Ch. Fieberi* var. *macropoda*, described by Spegazzini (**96**, p. 250) in 1898, and *Ch. globosum* Kze. Saccardo (**85**) redescribed this variety giving a much clearer diagnosis, and here again there is marked correspondence with Kunze's species. The only variation seems to lie in the spores which, as described by Saccardo, are slightly narrower than those of *Ch. globosum*. Since original specimens are not at hand it is impossible to come to a satisfactory conclusion regarding this variety.

It has already been pointed out that *Ch. rostratum*, published by Spegazzini (**96**) in 1899, may possibly be identical with *Ch. caprinum* Bainier, but since Spegazzini's description is not entirely clear, and no type material is at hand, it is impossible to decide the matter with certainty. This species has been reported by A. P. Morgan (**62**), who found it on rabbit dung at Preston, Ohio, and who kindly forwarded a specimen of his collection to the present writer. The perithecia obtainable from the specimens were very much broken, however, and only their most general characteristics could be made out.

SPECIES EXCLUDENDAE

As a result of a thorough examination of the literature concerning described species of *Chaetomium*, and notes published in connection with exsiccati, a considerable number of names have been found which should be excluded from further use. In some cases the plants to which the names were originally applied have apparently never been described, and there is every reason to believe that their characteristics will never be clearly understood. In other cases the published account is so brief and inadequate that it is impossible to arrive at a satisfactory conclusion regarding the form in question, while the descriptions of several other species indicate clearly that they are not *Chaetomia*. The following list includes all names whose further use should be discontinued for the reasons above mentioned.

In 1818 Ehrenberg (**28**, pp. 15, 27) contributed a new species, *Ch. gelatinosum*, which, according to Zopf (**113**, p. 204), is either an undeveloped condition of some other *Chaetomium*, or more probably a *Myxotrichum*, and which is placed by Saccardo (**79**) among his doubtful species. The original description, containing only a few of the most general statements, and with no accompanying figures, is entirely inadequate.

Fries (**38**) in describing a new species in 1829 under the name *Ch. pusillum*, overlooked one of the most salient characteristics of the genus pointed out by Kunze, namely,—the presence of an ostiole. This plant, possessing a minute, spherical, closed perithecium, with very short, stiff, opaque, bristle-like hairs, and producing spores which are at least one-septate, could hardly be classified as a *Chaetomium*. The same form has been observed by many authors since Fries's time, and has been given names as follows: *Acanthostigma Chaetomium* Auersw. (**1**); *Caelosphaeria exilis* (Alb. et Schw.) Sacc. (**79**); *Niesslia Chaetomium* (Cda.) Auersw. (**1**); *Niesslia exilis* (Alb. & Schw.) Wint. (**110**); *Niesslia pusilla* (Fries) Schroeter (**89**); *Nitschkia exilis* (Alb. & Schw.) Fckl. (**42**, p. 165); *Peziza aterima* Lasch; *Sphaeria Chaetomium* Cda. (**21**); *Sphaeria exilis* Alb. & Schw. (**2**, p. 44); *Sphaeria exosporioides* Desm. (**26**, No. 126); *Venturia Chaetomium* (Cda.) Ces. & DeNot. (**13**). The present writer has seen authentic specimens of *Ch. pusillum*, which were distributed by Fries in the Scleromyceti Sueciae XXVIII No. 272, and has found them to consist of small, black, naked pustules, not in the least resembling Chaetomia, scattered over the surface of the pine needles. Specimens under the same name and with the same characteristics have been distributed by Rehm in Ascomyceten No. 1762.

In 1833 Wallroth published, in the Flora Cryptogamica (**109**), eight new species which must be placed in the group of excluded names. They are as follows: *Ch. Alchemillae*, *Ch. circinans*, *Ch. coccodes*, *Ch. depressum*, *Ch. epiphyllum*, *Ch. oxysporium*, *Ch. Potentillae*, and *Ch. strigosum*.

Wallroth's original description of *Ch. Alchemillae* (**109**, p. 873) is incomplete and leaves one uncertain regarding the exact nature of the form. That part of the description which is clear, however, would seem to indicate that the plant was a *Ven-*

turia. Saccardo (**79**, **84**) has recorded it under the name *Venturia Alchemillae* (Grev.) B. & Br., while other authors have given names as follows: *Asteroma Alchemillae* Grev. (**37**, **44**); *Coleroa Alchemillae* (Grev.) Wint. (**110**, p. 199); *Dothidea Alchemillae* Rabh.; *Dothidea ceramioides* Duby (**27**); *Stigmatea Alchemillae* Fr. (**39**, p. 423).

The plant to which Wallroth (**109**, p. 266) gave the name *Ch. circinans* is clearly not a *Chaetomium*. Saccardo (**75**, **79**) has given to this form the name *Venturia Kunzei*, while other authors have applied the following names: *Coleroa Chaetomium* Rabh. (**71**, No. 1456); *Dothidea Chaetomium* Kze. (**51**); *Stigmatea Chaetomium* (Kze.) Fr. (**39**, p. 422).

The original description of *Ch. coccodes*, as given by Wallroth (**109**, p. 265), is very inadequate and it seems impossible to arrive at any satisfactory conclusion regarding it. Zopf (**113**, p. 205) has stated without further explanation that it probably represents a *Chaetomium*, but is rather to be considered as a slightly developed stage probably of *Ch. crispatum* Fckl.

Regarding *Ch. depressum* of Wallroth (**109**, p. 266) it may be said that the original description is hardly that of a *Chaetomium*, but rather of an *Excipula*, since the perithecia are described as depressed-globose, sometimes oval, rough at the base, whence arise short, rigid, black hairs, exposing at the apex, where they are wide open, a disc of sporophores.

The original diagnosis of *Ch. epiphyllum* Kze. appeared among the species of Wallroth (**109**, p. 265) mentioned above, as a note rather than as a description. The name was used by Kunze in connection with specimens which he enclosed in a letter to Wallroth, but so far as can be learned the species has never been described. Specimens of this species distributed in Klotzsch. Herb. Myc. No. 1347 are found to consist of minute, smooth, black pustules.

Ch. oxysporium Wallr. (**109**, p. 242) is merely mentioned by Wallroth in a description of a plant which he called *Fusarium Chaetomium*. It is a name which he himself had privately used for this form at an earlier date, but which he had never published.

The original description of *Ch. Potentillae* Wallr. (**109**, p. 266), while of a brief and general nature, would hardly indicate a true

Chaetomium. The perithecia were described as minute, black, with short, rigid hairs. Saccardo (**79**, p. 594) has listed this form under the name *Venturia Potentillae* (Fr.) Cke. (**18**). Other authors have placed it under the following names: *Coleroa Potentillae* (Fr.) Wint. (**110**, p. 199); *Dothidea Potentillae* Fr. (**37**, p. 563); *Stigmatea Potentillae* Fr. (**39**, p. 422).

The very brief diagnosis of *Ch. strigosum* Wallr. (**109**, p. 265) is vague and insufficient, and unaccompanied by figures. Rabenhorst (**71**, No. 1309) has called this *Ceuthospora phaeocomes*.

Schweinitz (**91**, p. 265) in 1834 added the new name *Ch. Typhae* to the genus, but the original description is scarcely more than a note. Type specimens from the Curtis herbarium, now at Harvard University, have been examined by the writer, but no material could be found on the stalks of the *Typha*. Considering the meagre description, there seems to be little reason for the continued use of this name or of the name *Ch. Typhinum*, which Schweinitz (**91**, p. 310) later used for this species.

In 1845 Léveillé (**52**) published diagnoses of two supposedly new forms; *Ch. Cumingii*, which he found on fallen leaves near Manila, and *Ch. viride*, on fallen grasses in Paraguay. The diagnoses, unaccompanied by figures of any kind, are brief and of such a general nature that one is unable to gain any satisfactory knowledge regarding the real nature of the plants in question. It would seem that the use of both names may well be discontinued.

The description of *Ch. hispidum*, published by Fries (**39**, p. 405) in 1849, is brief, calling attention only to the most general characteristics and to the hemispherical shape of the perithecium. No measurements of structures are given and it is impossible to arrive at a satisfactory conclusion regarding his material. The fact that the asci are four-spored would, in any case, exclude this species from *Chaetomium*.

In 1851 Bonorden (**9**) described *Ch. ciliatum* and Rabenhorst published in the Bot. Zeitung (**9**: 453) a description of *Ch. Braunii*. In the same year Preuss (**69**) described *Ch. concinnatum* and *Ch. tomentosum*, and in 1852 added still another name, *Ch. signatum*.

It may be seen from a study of Bonorden's description that the

plants which he called *Ch. ciliatum* are not *Chaetomia*, since the spores are cylindrical and provided at both ends with delicate cilia. Saccardo in the Sylloge Fungorum (**3**: 684) has given this plant a place under the name *Dinemasporium ciliatum* (Bon.).

Sections of the authentic material of *Ch. Braunii* Rabh., in Klotzsch. Herb. Myc. No. 1554, show the fruiting bodies to be stromatic, cellular, passing far down below the surface of the host tissue, black and coriaceous, covered with short, black, spine-like hairs.

The three species, *Ch. concinnatum*, *Ch. tomentosum*, and *Ch. signatum*, are described only in a most general way without measurements or illustrations. Rabenhorst, in Linnaea (**24**: 144), has questioned whether *Ch. tomentosum* is sufficiently different from *Ch. pannosum* Wallr., and has stated that in his specimen the hairs are soft, not rigid. A study of Rabenhorst's *Ch. tomentosum* in Klotzsch. Herb. Myc. No. 1856 shows his plants to be *Ch. murorum* Cda. No author, with the exception of Rabenhorst, has ever recorded the re-appearance of these forms and it would seem that the use of these names could well be discontinued.

In 1853 Strauss (**99**) published a diagnosis of what he considered a new species of *Chaetomium* under the name *Ch. nivale*, and Montagne (**61**) in 1856 added the name *Ch. raripilum*. The original description of *Ch. nivale*, together with the figures which Strauss published in connection with it, furnish sufficient evidence that he was dealing with a genus other than *Chaetomium*. This plant has been listed by Saccardo (**80**, p. 855) under the name *Acanthostigma nivale* (Str.). It is also evident from a study of Montagne's description that his plant is not a species of our genus. It is given a place by Saccardo in the third volume of the Sylloge (p. 322), under the name *Chaetomella raripila* (Mont.).

The description and simple figure of *Ch. fimeti*, published by Fuckel (**40**, p. 491) in 1861, are those of the plant which Zopf (**113**, p. 280) described and figured under the name *Chaetomidium fimeti*, and which was still later described and figured by Bainier (**3**, p. 192) under the same name. Exsiccati specimens of this form are to be found in Rehm Ascom. No. 991, and Fung. Sax. No. 370.

It has been possible to study type specimens in Fung. Rhenani No. 1572, of *Ch. paucisetum*, which was named by Fuckel (**41**) in 1866. The perithecia have been found to be globose, closed, black, firmly adnate to the surface of the substratum, and naked or bearing only a few short, scattered, slender, spine-like hairs. In Die Pilze Deutschlands (**110**, p. 65) this form is given the name *Chaetomella atra* (Fckl.).

In 1873 Berkeley and Broome (**7**) described *Ch. glabrum* and *Ch. rufulum*. The figures and descriptions of the first named species assure one that the plant is not a *Chaetomium*. It has been described by Cooke (**19**) as *Orbicula perichaenoides*, and by Saccardo as *Anixia perichaenoides* (**79**, p. 35). So far as *Ch. rufulum* is concerned there is no indication, either in the description or the figures, of the presence of perithecial hairs. The asci and the rough, spherical spores are not typical of *Chaetomium*.

Through the kindness of Dr. Saccardo it has become possible to examine type specimens of *Ch. calvescens* (**76**), described by that author in 1878. The specimens, however, are in such a condition that it is impossible to identify the plant in question with a great degree of accuracy. Only in one perithecium of the many which were mounted have any hairs been found, and in that case they are few and rather stiff and spine-like. In one perithecium the remains of a neck like that of *Melanospora* appears. The honey-yellow color of the apparently mature spores would indicate that the form is not a *Chaetomium*. In 1882, it was listed by its author (**79**, p. 227) under "Species Desciscentes."

Karsten (**47**) in 1881 described a plant under the name *Ch. fimisedum* which produced many spores in the ascus. No species typical of *Chaetomium* have been found to contain more or less than eight spores in their asci, and it seems reasonable to conclude that forms with a varying number of spores should be listed in another genus.

In 1882 Rehm (**73**) added the new name *Ch. Polypori* to the genus, and while authentic specimens are not at hand the original description indicates that these plants are not *Chaetomia* since the perithecia are minute, and clothed with very short, acute

setae. The asci are cylindrical and contain subrotund or spherical spores arranged in a single row, and filiform paraphyses are produced among the asci.

During the following year 1883, Roumeguère and Patouillard, in Rev. Myc. (**5**: 29), applied the name *Therryana* to a variety of *Ch. atrum* Link. A study of the original description and the accompanying figures together with an examination of authentic specimens in Fung. Gall. No. 2496, are sufficient to convince the writer that this variety has nothing in common with *Ch. atrum* but is identical with *Chaetomidium fimeti* (Fckl.) Zopf. During the same year Therry (**102**) made mention of *Ch. exile*, and whether he used this name by mistake or whether he purposely used it for a species which he intended to describe later, is uncertain. In either case it would seem advisable to exclude this, since, so far as can be learned, no reference has since been made to it, and no description has been published.

In 1888 Roumeguère gave to a plant in Fung. Gall. No. 4438, the name *Ch. globosum* Kze., f. *chartarum*. The variety was not described, however, and so far as can be learned no mention or description has since appeared. From a study of mounted material from the authentic specimens, this plant is found to be identical with *Chaetomidium fimeti* (Fckl.) Zopf.

In 1892 Dr. Cavara (**12**) described under the name *Ch. Montemartinii* a form which has characteristics similar to those of *Ch. Calvescens* Sacc. In this case, however, mounts of the type material received from Dr. Saccardo, and also of authentic exsiccati specimens in Fung. Longob. No. 228, show more clearly the exact nature of the plant. The perithecia, naked or scantily clothed with a few very slender, short hairs, are globose, flattened at the base, while from the top extends a cylindrical, curved neck, 70–80 μ in length. At the top of the neck an ostiole is located. In spite of several attempts to obtain asci none have been found. The honey-yellow spores which are produced in the perithecium and which in mass possess a decided orange tinge are poured from the ostiole in enormous numbers whenever pressure is brought to bear on the perithecium. From these observations it may be seen that this plant is not a *Chaetomium*.

In 1894 Ellis and Everhart (**34**) described as new *Ch. palli-*

dum, and through the kindness of Mr. J. Dearness the study of this form from original material has been made possible. This plant seems to possess characteristics entirely in common with those of *Melanospora*, and ought therefore, as suggested by Palliser in the North American Flora (**65**, p. 64), to be listed in that genus. *Ch. marchicum*, described by Lindau (**53**) two years later, also possesses characteristics of a *Melanospora*. According to the original description and figures a mouth or ostiole is formed at the top of the perithecium and this is surrounded by a few stiff bristles. In this area the adjacent wall cells become somewhat elongated. Saccardo (**83**, p. 627) has given to this form the name *Sphaeroderma marchicum*.

In 1898 Ellis and Everhart (**36**) described as new *Ch. Abietinum*, and Hennings (**46**, pp. 153 and 154) described two new species using the names *Chaetomium ? importatum* and *Ch. laeliicola* respectively.

Through the kindness of the New York Botanical Garden, plants from the original specimens of *Ch. Abietinum* E. & E. have been placed at the disposal of the writer, and a detailed study of that species has been made. The conclusion has been reached that the plants in question cannot be included in our genus. In mounts of the type material the perithecia are black, opaque and somewhat coriaceous, firmly adnate to the substratum of wood upon which they are growing, lacking an ostiole, and very densely covered throughout with short, stout, spine-like hairs typical more of *Coleroa* or *Venturia* than of *Chaetomium*. According to the original description the species is allied to *Ch. sphaerospermum* E. & E. The bristles, however, are not branched and the sporidia are rather larger and only slightly compressed. At first sight the spores are similar to those of *Ch. sphaerospermum* E. & E. which in this paper has been listed as a synonym under *Ascotricha chartarum* Berk., but with more careful study one finds that the spores are only slightly compressed and lacking in a girdle.

A study of the two authentic specimens kindly sent by Dr. Lindau, to which Hennings gave the name *Chaetomium ? importatum* and *Ch. laeliicola* respectively, is sufficient to convince one that neither of these plants can be regarded as a *Chaetomium*. The first named species appears as dark, chocolate-

brown or black, irregular pustules, with here and there stiff, dark bristles near the margin of the pustules. It has little resemblance to a *Chaetomium*. Mounts of authentic specimens of *Ch. laeliicola*, to which Saccardo (85, p. 429) has later referred as *Ch. laeliicolum*, show the plants to be in the form of irregular pustules erupted through the epidermis of the host, from which arise stout, dark, septate hairs. Sections of the same material show the fruiting bodies to be sunk deeply below the surface of the tissue of the substratum on which they grow.

In 1900 Cocconi (15) gave the name *Ch. papillosum* to a plant which he found on rotting wood in a field at Bologna, and which resembles a *Magnusiella* in certain of its characteristics, and *Ch. murorum* Cda. in others, yet differs from both in some respects. He described and figured this form as having a small, globose perithecium, perforated at the apex by an ostiole, and with hairs diverging in all directions. At the apex the perithecium was rather scantily supplied with abruptly incurved hairs. The asci were cylindrical, with their spores arranged in a single row. According to Cocconi experiments with cultures of this plant demonstrated on the one hand the formation of a pycnidial stage which produced two-celled spores, and on the other, the formation of branched conidiophores bearing spores in a clump at the tips of the branches.

In 1902 Massee and Salmon (59) published a diagnosis of *Ch. arachnoides*. At first sight mounted specimens of this form, which were received from the Royal Botanic Gardens at Kew, may be easily mistaken for a *Chaetomium*, but with more careful examination characteristics appear which are sufficient to exclude it from this genus. At the top of the perithecium is a long neck resembling that of a *Melanospora*, and it is from the neck that the hairs arise which form at maturity a tangled mass, and which closely resemble the hairs of *Ch. murorum* Cda. The spores at maturity are honey-yellow in color, a characteristic unusual for *Chaetomium* spores.

There are three scattered nomina nuda which have been found in literature unaccompanied by description or figures, and regarding which little is known. Material under the name of *Ch. Bromelliae* Schw. has been found in the Curtis herbarium,

but no further mention or description has been published. The plants here included are evidently not Chaetomia, for they consist of spherical or elongated, black pustules, firmly attached to the substratum by a broad base. There are no hairs with the exception of a few bases of stout hyphae at the sides of the fruiting body. No spores could be obtained. The material in the Curtis herbarium which, according to a note, came from the herbarium of Schweinitz, and which undoubtedly represents authentic specimens, appears to be an *Epicoccum*.

In the Nomenclator Fungorum of Streinz (100, p. 183) is found the following: "*Chaetomium Montagnei* Brond. in litt. ad M." This manuscript name, apparently used by Brondeau in a letter to Montagne, seems never to have been published. In the reference quoted it is said to be identical with *Ch. murorum* Cda.

In the Curtis herbarium is to be found under No. 5978 the name *Ch. subnudum* B. & C. Examination of material here contained, which must have been collected previous to 1872, shows the fruiting bodies to be of the nature of pustules sunken in the tissues of the host, black and round or elongated. The spores are dark bronze and one-septate. It is evident that the material is not that of a *Chaetomium* and so far as can be learned no description has ever appeared.

THE GENUS ASCOTRICHA, HISTORICAL REVIEW

A description of the genus *Ascotricha* was first published by M. J. Berkeley in the Annals of Natural History (5, p. 257). The characteristics were there cited as follows: "Peridium thin, at length bursting, clothed with dark, sub-pellucid, even, obscurely jointed hairs; sporidia simple, contained in linear asci. Superficial, at length free or only supported by the investing thallus, black." In connection with his account of the genus, he gave a very full and complete description of a single species, *As. chartarum*, and illustrated the same with six figures. Only one other form similar to that published by Berkeley is known. This was first described by Ellis in 1890, in the Proceedings of the Academy of Natural Sciences of Philadelphia, page 220, under the name *Ch. pusillum*.

In 1871 Cooke included this genus in the Handbook of British

Fungi (2: 653), and defined it as follows: perithecium thin, free, astomate, seated on loose, branched, conidiophorous threads; sporangia linear, containing dark, elliptical sporidia.

These fungi should not be considered as true *Chaetomia*, but rather as species of an allied genus. The spherical perithecia, almost naked below and constricted at the top into a neck from which the terminal hairs arise, the curious stiff or whip-like ampullate hairs bearing large numbers of conidia, and the disc-shaped spores of one of the species, afford a sufficient basis for separating these forms from the genus *Chaetomium*. The earlier writers mentioned above were not aware that the perithecia of *Ascotricha* were provided with an ostiole, for Berkeley stated that the perithecia finally burst, and Cooke described them as astomous. Otherwise their descriptions are reasonably clear, and it therefore seems best to restore Berkeley's original name *Ascotricha* to his species, and to change the name of *Ch. pusillum* E. & E. to *Ascotricha pusilla*.

CHARACTERS OF THE GENUS ASCOTRICHA

Perithecium when young subconical, dark green and translucent, when mature spherical or nearly so below, constricted above into a narrow and distinct neck, perforated by a central ostiole. Differentiated rhizoids lacking. Perithecial wall brittle, membranaceous. Lateral hairs colored and branched, varying in number, sometimes numerous, but at times almost wanting. Terminal hairs numerous, arising from the region of the neck, branched sympodially, and distinguished by the presence of clavate ampullae. Asci linear, cylindrical, 8-spored. Spores arranged in a single row in the ascus, simple, dark colored, discharged from the ostiole in a black cylindrical cirrhus.

KEY TO THE SPECIES OF ASCOTRICHA

Perithecial hairs and conidiophores slender, frequently gracefully flexed, sparingly branched. Conidia 5.5 × 3.5 μ, smooth or nearly so. Ascospores ovate to egg-shaped, 5.5 × 4 μ.	1. *As. pusilla* (p. 220).
Perithecial hairs and conidiophores stout, profusely branched. Conidia 6 × 5 μ, roughened by minute wart-like projections. Ascospores disc-shaped, 8 × 7.5 μ.	2. *As. chartarum* (p. 222).

Ascotricha pusilla (Ellis & Everhart) comb. nov.

Chaetomium pusillum Ellis & Everhart, Proc. Acad. Nat. Sci. Phil. **1890**: 220. 1890.

Chaetomium Ellisianum Saccardo & Sydow, Syll. Fung. **14**: 491. 1899.

PLATE 17, FIGS. 13–21

Black. Perithecia small, globose, the body somewhat broader than long, constricted above to form a distinct neck, 151 × 166 μ (135–190 × 139–202), extruding long, black cirrhi, rather firmly adnate to the substratum and associated with numerous conidiophores. Lateral hairs when present sparsely scattered over the upper portion of the perithecium wall, slender, whip-like, more or less flexed or gracefully recurved to form a loop, tapering almost imperceptibly, evenly and remotely but obscurely septate, slightly swollen at the septa, near the base dark olive-brown to black and about 5.6 μ in thickness, becoming pale olive at the tips, unbranched except very rarely when the short main axis produces an extremely long, whip-like outgrowth just above the origin of which the axile portion terminates in a club-shaped, hyaline ampulla. Terminal hairs arising in the region of the neck, extremely long, slender, whip-like, graceful, smooth and even, with the exception of slight angular swellings at the septa, flexed and often recurved forming a loop, septate but so dark below that the septa are nearly obscured, very dark olive to black and about 5.6 μ in thickness at the base, almost imperceptibly tapering and fading toward the pale olive tip, unbranched except in rare cases, where branching takes place in the same manner as described above for the lateral hairs. Asci extremely delicate, linear, cylindrical, 8-spored, 60 × 6 μ, pars sporif. 43 μ. Spores monostichous, hyaline when young, when mature dark olive-brown, ovate, roughly egg-shaped, rounded at both ends, 5.6 × 4.2 μ (5.4–6 × 3.5–4.5), when seen edgewise, compressed, 3.2 μ broad.

On barrels in cellar, Cambridge, Massachusetts, and Kittery Point, Maine, herb. R. Thaxter; on barrel hoops and packing boxes in cellar in Hanover, New Hampshire, and Amesbury, Massachusetts (Chivers No. 41). Reported also by G. F. Atkinson from Alabama, growing on old paper.

Type locality: as *Ch. pusillum* E. & E., Newfield, New Jersey; on basswood barrel bottom in cellar. Also Manhattan, Kansas; on an old churn in cellar (Kellerman 1437).

The original material of this species was collected by Ellis

at Newfield, New Jersey, and described by him as *Chaetomium pusillum*, in apparent ignorance of the fact that this combination had already been employed by Fries (38) for a different plant. For this reason a new name *Ch. Ellisianum* was proposed by Saccardo in the fourteenth volume of the Sylloge, p. 491, but since for reasons already stated it has seemed best to recognize the genus *Ascotricha*, it becomes necessary to return to the original specific name used by Ellis, and to employ a new combination in designating this species.

Conidial growth precedes the development of the perithecia. The conidiophores when young are grayish-green to the naked eye, while at maturity they are black. Under magnification they appear long and slender, rather sparingly branched, at the base dark olive-brown to black and about 3.5 μ in thickness, tapering and fading toward the tip, one to several times sympodially branched, the individual axes producing a lateral branch, above the point of origin of which the axis terminates in a clavate, hyaline ampulla. The lower branches in turn become verticillately branched, and bear large clusters of ovate to globose conidia which are hyaline when young, olive-brown at maturity, and measure $5.4 \times 3.6\ \mu$, appearing smooth except with an immersion lens when a slight irregularity of the wall is apparent. In the mounts most favorable for study the threads of the mycelium are woven together into rope-like strands, along which conodiophores branch forth in large numbers and perithecia take their origin.

The species appears to be by no means rare in this country and may frequently be found often in company with other interesting forms growing on the bottom of barrels which have stood for some time in a damp situation, as for example on a cellar bottom. It may quickly be recognized by its jet black color and the characteristic mingling of perithecia and conidiophores with black masses of conidia and ascospores. This species may easily be distinguished from *Ascotricha chartarum*, which it most nearly resembles, by the following differences: the smaller perithecia, the extremely long, whip-like hairs which are frequently gracefully looped, but seldom branched, and the much smaller spores, which are egg-shaped instead of disc-shaped, and without a girdle.

ASCOTRICHA CHARTARUM Berkeley, Ann. Nat. Hist. 1: 257. *pl. 7, f. 8.* 1838

Ascotricha Zopfii (Boul.) Peyronel, Ann. Myc. 12: 459–470. *f. 1–3.* 1914.

Chaetomium Berkeleyi Schroeter; Cohn, Krypt.-Fl. Schlesien 3: 284. 1894.

Chaetomium chartarum Winter, Rabenhorst's Kryptogamen-Flora 1^2: 157. *f. 4–7.* 1885. Not *Chaetomium chartarum* Ehrenberg, Sylv. Berol. 27. 1818.

Chaetomium delicatulum Roumeguère, Rev. Myc. 7: 22. 1885.

Chaetomium sphaerospermum Cooke & Ellis, Grevillea 8: 16. 1879.

Chaetomium Zopfii Boulanger, Rev. Gén. Bot. 9: 25. *pl. 1–3.* 1897.

Dicyma ampullifera Boulanger, *l. c.* 9: 17. *pl. 1–3.* 1897.

Sporotrichum sp. Boulanger, *l. c.* 9: 17. *pl. 2.* 1897.

PLATE 17, FIGS. 1–12

Black. Perithecia rather small, globose or subglobose, constricted into a neck at the upper extremity, frequently flattened at the base, 192 μ high × 198 μ broad (126–232 × 135–236), discharging black spore cirrhi many times longer than the perithecium, producing no differentiated rhizoids, but seated among and upon the stalks and branches of the conidiophores. Lateral hairs rather numerous, very variable in length but nearly always short, tapering near the tips only, branched and ampullate as are the terminal hairs, very dark olive-brown to black below, about 3.2 μ in thickness near base, colorless and frequently septate near their tips. Terminal hairs extremely variable in length, straight, stiff, dark olive-brown to black except at the ampullae and extreme tips, remotely septate, frequently with an angular swelling at the septum, profusely and sympodially branched, each individual axis producing one or two lateral branches beyond the point of origin of which the axis terminates in a somewhat swollen, club-shaped colorless ampulla. Asci linear, cylindrical, 8-spored, 65 × 11 μ, pars sporif. 45 μ. Spores monostichous, when young pale olive with a greenish tinge, when mature dark olive-brown to black, regularly or irregularly circular in face view, lenticular, with girdle apparent when seen in profile, 8.1 × 7.7 μ (7.2–9 × 7.2–8.1), when seen edgewise 4.5–5.4 μ broad.

EXSICCATI.—Fung. Europ. Edit. nova, Series II, XXV, 2472; Micro-Fung. Brit. IV, 348, 355 and V, 474; Myc. Ital. I, 63;

Myc. March. 69. Sub *Ch. delicatulum* Roum.: Fung. Gall. XXXII, 3143.

On cardboard, Cambridge, Massachusetts, Herb. R. Thaxter. On barrel bottoms from various localities in New England (Chivers No. 40). Reported also from different parts of the United States, South America, and Germany. Type locality: King's Cliffe, England; on a candle box.

The species was first observed in America by Ellis and was communicated to Cooke who described it as *Ch. sphaerospermum*, as indicated in the above synonymy. The writer has been able to examine specimens of the original material collected by Ellis, and has found it to be identical in every respect with *Ascotricha chartarum*.

Although this species appears to be so clearly characterized it has been repeatedly re-described, first in 1879 by Cooke and Ellis as above mentioned.

In 1885 Winter in his Pilze Deutschlands (**110**, p. 157) includes this species under the name *Ch. chartarum*, in apparent ignorance of the fact that this combination had already been used by Ehrenberg (**28**, p. 27) for a wholly different plant, and in the same year Roumeguère added still another name to the list by re-describing this plant as *Ch. delicatulum*, since an examination of the description given by him, as well as a study of the authentic specimens distributed in Fung. Gall. No. 3143, leave no doubt as to its synonymy.

Schroeter (**89**) in 1894, being aware of the previous use of the name *Ch. chartarum* by Ehrenberg, but following Winter in his generic reference of the present species, completed the list of synonymy by adding yet another name *Ch. Berkeleyi*.

In 1897 the form was redescribed under the new name *Ch. Zopfii* by Boulanger (**10**), to whom we owe a very complete account of its morphology and development. This author made excellent figures which place the identity of the plant which he had before him beyond question.

During the publication of this paper the writer has noted an article by Peyronel (**68**), in which he transfers this species from the genus *Chaetomium* to that of *Ascotricha*, still retaining Boulanger's specific name. As there seems to be no doubt that *Ch.*

Zopfii Boulanger is identical with *Ascotricha chartarum*, described by Berkeley in 1838, it seems to the present writer more desirable to return to the use of the original name given by Berkeley than to continue the names given by more recent authors.

As in *Ascotricha pusilla* conidial growth precedes the formation of perithecia. The conidiophores to the naked eye are greenish-gray when young and black at maturity. Under magnification they are dark olive-brown to black near their base and about 5 μ in thickness, clearly but irregularly septate and very profusely and sympodially branched, each individual axis producing a single branch, or forking and producing two symmetrical branches beyond the point of origin of which the axis terminates in a colorless, clavate ampulla. This may be several times repeated and the peripheral branches thus produced may form an irregular whorl, from which arise clusters of conidia which are roughly spherical, ovate or egg-shaped, roughened by minute warts, hyaline when young and olive-yellow or olive-brown when mature, 6.1 × 5.1 μ (5.4–7.2 × 3.6–5.9).

This species is most often found on paper and cardboard, but like *As. pusilla*, the only form with which it is in danger of being confused, it occurs frequently on barrels or boxes in cellars. A comparison shows at once that in the case of the former the perithecium is of greater average size, the hairs are much stiffer, straighter, and more profusely branched, the spores are larger and easily distinguished by the fact that they are circular in face view, but lenticular with a girdle at the margin, when seen in profile.

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In the following bibliography only the more important references have been included and no attempt has been made to list the numerous references which indicate simply the distribution of the various species.

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EXSICCATI

The writer's conclusions have for the most part been based on the exsiccati specimens in the Cryptogamic Herbarium at Harvard University.

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EXPLANATION OF PLATES 6–17

Unless otherwise indicated all figures are drawn with the following magnifications: perithecia × 47, lateral and terminal hairs × 180, asci × 390, spores × 390.

PLATE 6

CHAETOMIUM ELATUM Kunze & Schmidt

FIG. 1. Mature perithecium.
FIG. 2. Lateral hair.
FIG. 3. Terminal hair.
FIG. 4. Ascus.
FIG. 5. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) mature spore seen edgewise.

CHAETOMIUM TRIGONOSPORUM (Marchal) Chivers

FIG. 6. Mature perithecium showing the relative size of the spore mass, × 25.
FIG. 7. Mature perithecium.
FIG. 8. Lateral hair.
FIG. 9. Terminal hair.
FIG. 10. Asci showing variation in shape.
FIG. 11. Spores. (*a*) Young spores with oil globules; (*b*) mature spore seen in face view; (*c*) mature spores seen edgewise.

PLATE 7

CHAETOMIUM INDICUM Corda

FIG. 1. Mature perithecium.
FIG. 2. Terminal hair showing the characteristic dichotomy and reflexed branches.
FIG. 3. Distal portion of a terminal hair showing the encrustation of calcium oxalate.
FIG. 4. Terminal hair of a different character showing dichotomy and narrow acute angles.
FIG. 5. Distal portion of the same hair at a much older stage when its surface has become encrusted with calcium oxalate.
FIG. 6. Lateral hair.
FIG. 7. Ascus.
FIG. 8. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) mature spore seen edgewise.

CHAETOMIUM FUNICOLUM Cooke

FIG. 9. Mature perithecium.
FIG. 10. Mature perithecium with slightly greater magnification, showing a variation in which the terminal hairs do not form a dense mass.
FIG. 11. Lateral hair.
FIGS. 12, 13. Terminal hairs showing dichotomy.
FIGS. 14, 15. Distal portion of terminal hairs showing the encrustation of calcium oxalate.
FIGS. 16, 17. Asci.
FIGS. 18, 19. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) seen edgewise.

Note.—It at first seemed to the writer that the form represented by figure 10 could well be considered a variety of *Ch. funicolum*, but it has since been found that the variation is not constant.

PLATE 8

CHAETOMIUM CIRCINATUM Chivers

FIG. 1. Mature perithecium.
FIG. 2. Terminal hair.
FIG. 3. Terminal hair showing an extreme case of circinate coiling.
FIG. 4. Ascus.
FIG. 5. Spores. (*a*) Young spore with oil globules; (*b*) mature spore; (*c*) mature spore showing the characteristic furrow caused by the collapse of the spore wall.

CHAETOMIUM MURORUM Corda

FIG. 6. Mature perithecium.
FIG. 7. Terminal hair.
FIGS. 8, 9. Asci showing their varying shape.
FIG. 10. Spores. (*a*) Young spores with oil globules; (*b*) mature spores; (*c*) mature spore showing the characteristic furrow caused by the collapse of the spore wall.

PLATE 9

CHAETOMIUM SIMILE Massee & Salmon

FIG. 1. Mature perithecium.
FIG. 2. Terminal hair.
FIG. 3. Ascus, copied from the original drawing by Massee and Salmon, × 400 and reduced by one half.
FIG. 4. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) mature spore seen edgewise.

CHAETOMIUM CRISPATUM Fuckel

FIG. 5. Mature perithecium.
FIGS. 6, 7. Terminal hairs showing the variation in the manner of coiling.
FIG. 8. Ascus.
FIG. 9. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) mature spore seen edgewise.

CHAETOMIUM CONTORTUM Peck

FIG. 10. Mature perithecium.
FIG. 11. Terminal hair.
FIG. 12. Spores. (*a*) Young spores with oil globules; (*b*) and (*c*) mature spores.

CHAETOMIUM TORTILE Bainier

FIG. 13. Mature perithecium.
FIG. 14. Terminal hair.
FIG. 15. Terminal hair, distal portion showing the variation in the manner of coiling.
FIG. 16. Ascus.
FIG. 17. Spores. (*a*) Mature spores seen in face view; (*b*) seen edgewise.

PLATE 10

CHAETOMIUM SPINOSUM Chivers

FIG. 1. Mature perithecium.
FIG. 2. Mature perithecium showing the steeple-like cirrhus of spores.

FIG. 3. Terminal hair with branches.
FIG. 4. Distal portion of a branch of the terminal hair.
FIGS. 5, 6. Asci in different stages of development.
FIG. 7. Spores. (*a*) Young spores with oil globules; (*b*) mature spore.

CHAETOMIUM AMPULLARE Chivers

FIG. 8. Mature perithecium showing the relative size of the spore mass, × 25.
FIG. 9. Mature perithecium.
FIG. 10. Terminal hair.
FIG. 11. Ascus.
FIG. 12. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) seen edgewise.

CHAETOMIUM GLOBOSUM Kunze

FIG. 13. A germinating spore showing the cast-off exospore and the persistent endospore, × 390.
FIG. 14. A slightly later stage, showing the origin of the mycelial branches from the endospore.
FIG. 15. A germinating spore in which the endospore does not appear as a persistent vesicle.
FIG. 16. A diagrammatic drawing of the mycelium, showing its radial growth.

PLATE 11

CHAETOMIUM TRILATERALE Chivers

FIG. 1. Mature perithecium.
FIG. 2. Mature perithecium under greater magnification, × 94.
FIG. 3. Lateral hair.
FIG. 4. Terminal hair.
FIG. 5. Ascus.
FIG. 6. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) mature spore seen edgewise.

CHAETOMIUM FUSIFORME Chivers

FIG. 7. Mature perithecium.
FIG. 8. Mature perithecium under greater magnification, × 94.
FIG. 9. Terminal hair.
FIG. 10. Ascus.
FIG. 11. Spores. (*a*) Mature spores seen in face view; (*b*) seen edgewise.

CHAETOMIUM AUREUM Chivers

FIG. 12. Mature perithecium.
FIG. 13. Mature perithecium under greater magnification, × 94.
FIG. 14. Mature perithecium showing the relative size and characteristic curvature of the spore cirrhus, × 25.
FIG. 15. Terminal hair.
FIG. 16. Ascus.
FIG. 17. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) mature spore seen edgewise.

CHAETOMIUM SPHAERALE Chivers

FIG. 18. Mature perithecium.
FIG. 19. Mature perithecium showing the relative size of the spore mass, × 20.
FIG. 20. Lateral hairs. (*a*) Short and sinuous; (*b*) somewhat longer, nearly straight and unbranched; (*c*) still longer and branched.
FIG. 21. Terminal hair.
FIG. 22. Ascus.
FIG. 23. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) seen edgewise.

PLATE 12

CHAETOMIUM ATERRIMUM Ellis & Everhart

FIG. 1. Mature perithecium.
FIG. 2. Lateral hair.
FIG. 3. Terminal hair.
FIG. 4. Spores. (*a*) Mature spores seen in face view; (*b*) mature spore seen edgewise.

CHAETOMIUM SPIRALE Zopf

FIG. 5. Mature perithecium.
FIG. 6. Terminal hair.
FIG. 7. Lateral hair.
FIG. 8. Spores. (*a*) Mature spores seen in face view; (*b*) mature spore seen edgewise.

PLATE 13

CHAETOMIUM BOSTRYCHODES Zopf

FIGS. 1, 2, 3. Mature perithecia showing the characteristic variation.
FIG. 4. Terminal hair, branched and irregularly convolute.
FIG. 5. Terminal hair, regularly spirally coiled.
FIG. 6. Terminal hair, branched and regularly spirally coiled with ten coils.
FIG. 7. Portion of a terminal hair showing the encrustation of calcium oxalate.
FIGS. 8, 9, 10. Asci, showing different stages of development.
FIG. 11. Spores. (*a*) Mature spores seen in face view showing a characteristic refractive area at each end; (*b*) mature spores seen edgewise.

CHAETOMIUM SUBSPIRALE Chivers

FIG. 12. Mature perithecium.
FIG. 13. Mature perithecium showing the relative size of the spore mass, × 15.
FIG. 14. Lateral hair.
FIG. 15. Terminal hair.
FIG. 16. Ascus.
FIG. 17. Spores. (*a*) Young spores with oil globules; (*b*) mature spores seen in face view; (*c*) seen edgewise.

CHAETOMIUM CAPRINUM Bainier

FIG. 18. Mature perithecium.
FIGS. 19, 20. Terminal hairs with branches.
FIG. 21. Ascus.
FIG. 22. Spores. (*a*) Young spore with oil globules; (*b*) mature spores seen in face view; (*c*) mature spore seen edgewise.

PLATE 14

CHAETOMIUM QUADRANGULATUM Chivers

FIG. 1. Mature perithecium with the greater portion of the spore mass removed.
FIG. 2. Mature perithecium.
FIG. 3. Mature perithecium showing the relative size of the spore mass, × 15.
FIG. 4. A spirally coiled terminal hair.
FIG. 5. An irregularly convolute terminal hair with branches.
FIG. 6. Ascus seen in face view.
FIG. 7. The same ascus seen edgewise.
FIG. 8. Spores. (*a*) Mature spores seen in face view; (*b*) seen edgewise; *c*.) grouped in a characteristic manner.

CHAETOMIUM CONVOLUTUM Chivers

FIG. 9. Mature perithecium.
FIG. 10. Terminal hair.
FIG. 11. Ascus.
FIG. 12. Spores. (*a*) Young spore with oil globules; (*b*) mature spore seen in face view; (*c*) mature spores seen edgewise.

PLATE 15

CHAETOMIUM COCHLIODES Palliser

FIG. 1. Mature perithecium.
FIG. 2. Mature perithecium, showing the relative size of the spore mass, × 15.
FIG. 3. Lateral hair.
FIG. 4. A slender, spirally coiled terminal hair.
FIG. 5. A slender, sinuous terminal hair with branches.
FIG. 6. A stout, spirally coiled terminal hair.
FIG. 7. Ascus.
FIG. 8. Spores. (*a*) Young spores with oil globules; (*b*) mature spore seen in face view; (*c*) seen edgewise.

CHAETOMIUM GLOBOSUM Kunze

FIG. 9. Mature perithecium.
FIG. 10. Mature perithecium showing the relative size of the spore mass.
FIG. 11. Terminal hair.
FIG. 12. Ascus.
FIG. 13. Young spores with oil globules.
FIG. 14. Mature spores.

PLATE 16

CHAETOMIUM TORULOSUM Bainier

FIG. 1. Mature perithecium.
FIG. 2. Lateral hairs.
FIG. 3. Terminal hair with branches.
FIG. 4. Ascus.
FIG. 5. Spores. (*a*) Large spore when young with oil globules; (*b*) large mature spores seen in face view; (*c*) small spores when young with oil globules; (*d*) small mature spores seen in face view; (*e*) spores seen edgewise.

CHAETOMIUM ANGUSTUM Chivers

FIG. 6. Mature perithecium.
FIG. 7. A straight terminal hair. For convenience the hair is figured in two parts.
FIG. 8. A slender terminal hair spirally coiled near its tip.
FIG. 9. A stout terminal hair spirally coiled near its tip.
FIG. 10. An irregularly convolute terminal hair with a branch. For convenience the hair is figured in two parts.
FIG. 11. Ascus.
FIG. 12. Spores. (*a*) Young spores with oil globules; (*b*) and (*c*) mature spores seen in face view; (*d*) seen edgewise.

PLATE 17

ASCOTRICHA CHARTARUM Berkeley

FIG. 1. Mature perithecium.
FIG. 2. A perithecium developing from the rope-like mycelial strand, × 15.
FIG. 3. Terminal hair, showing its ampullate swellings.
FIG. 4. Terminal hair of slightly different character.
FIG. 5. Conidiophore with its clusters of conidia, × 180.
FIG. 6. A portion of a conidiophore under greater magnification, × 390.
FIG. 7. A small portion of a conidiophore with four conidia, × 390.
FIG. 8. Conidia, × 390.
FIG. 9. Conidiophores developing from the rope-like mycelial strand, × 25.
FIG. 10. A young ascus.
FIG. 11. A mature ascus.
FIG. 12. Spores. (*a*) Seen in face view; (*b*) seen edgewise showing their girdle.

ASCOTRICHA PUSILLA (Ellis & Everhart) Chivers

FIG. 13. Mature perithecium.
FIGS. 14, 15. Terminal hairs showing their ampullate swellings.
FIG. 16. Conidiophore with its cluster of conidia, × 180.
FIG. 17. Conidiophore of a slightly different character, × 180.
FIG. 18. A portion of a conidiophore under greater magnification, × 780.
FIG. 19. Conidia, × 390.
FIG. 20. Ascus.
FIG. 21. Spores. (*a*) and (*b*) seen in face view; (*c*) edgewise.

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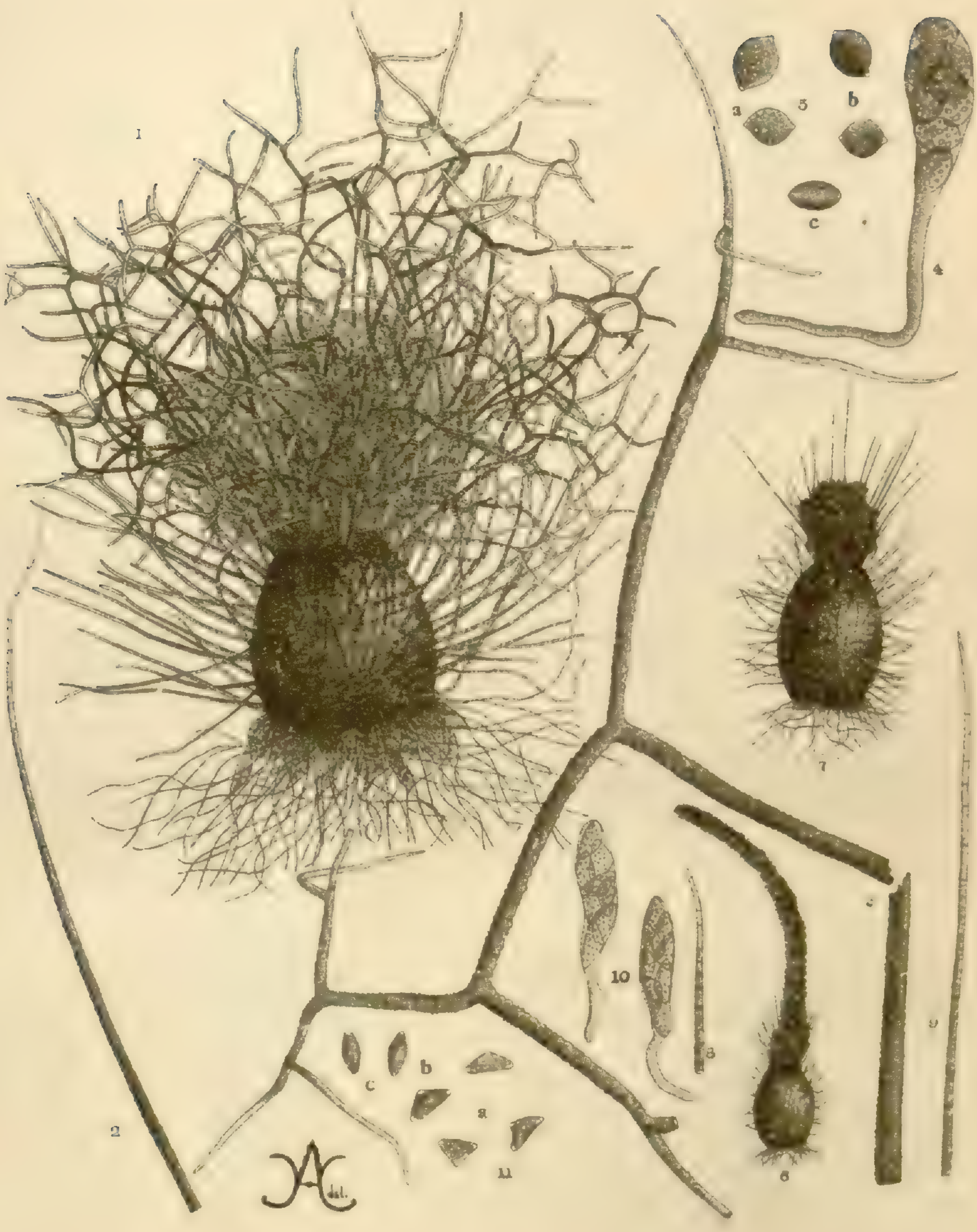
New names, the final members of new combinations, and the numbers of the pages on which the descriptions are to be found are in *bold face type.*



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6-11. CHAETOMIUM TRIGONOSPORUM (MARCHAL) CHIVERS

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9-19. CHAETOMIUM FUNICOLUM Cooke

1-5. CHAETOMIUM CIRCINATUM CHIVERS
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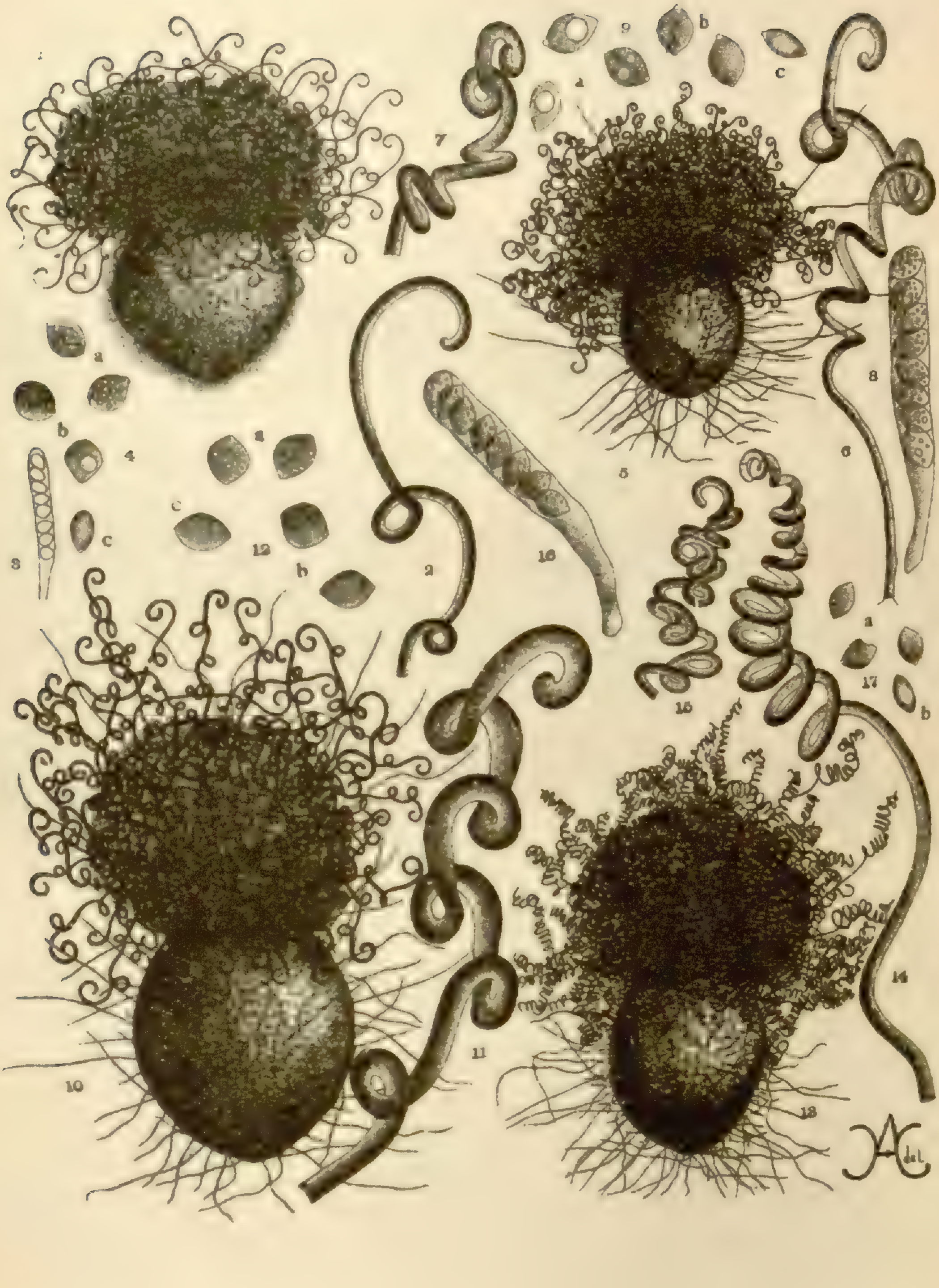

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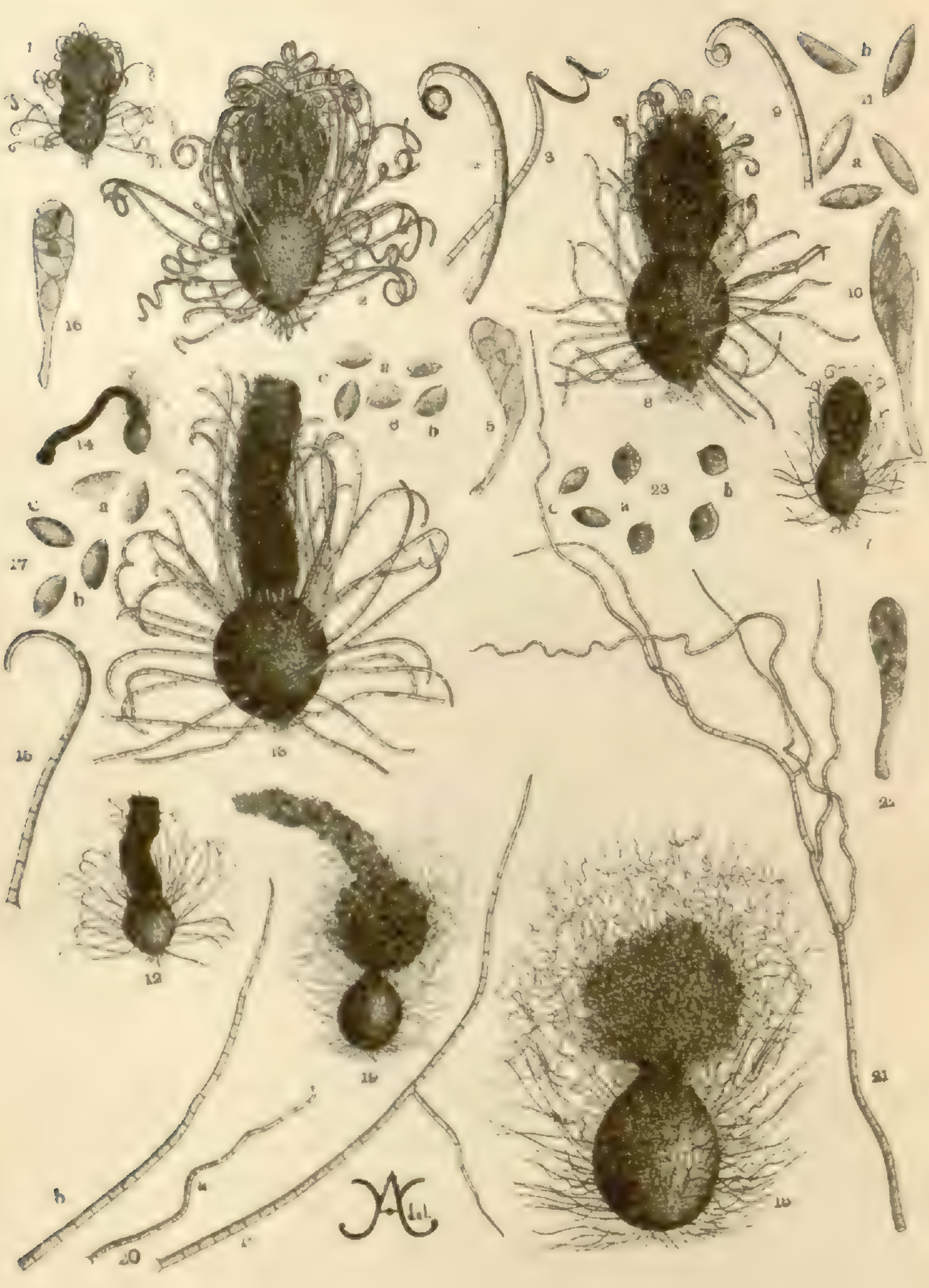

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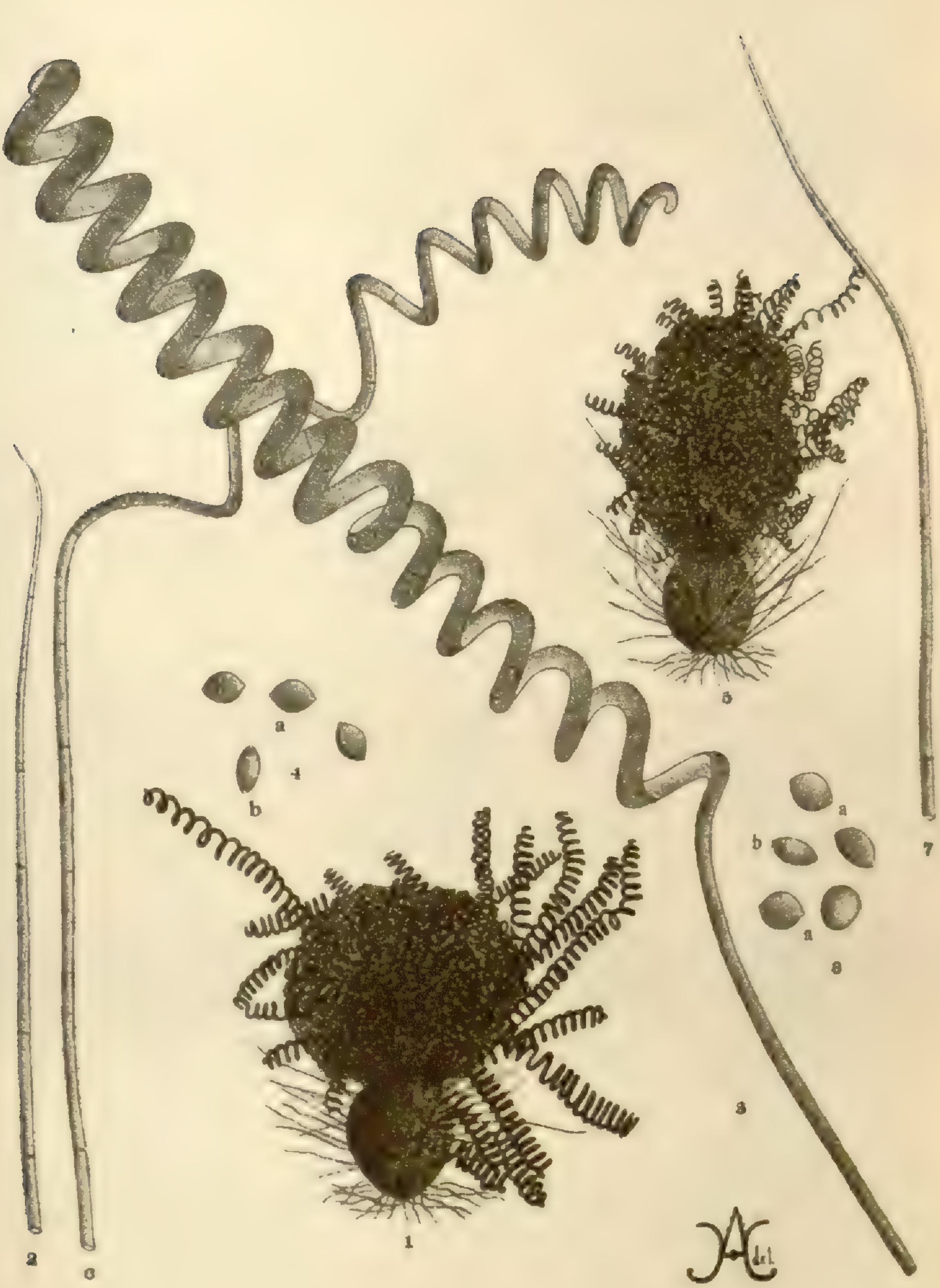

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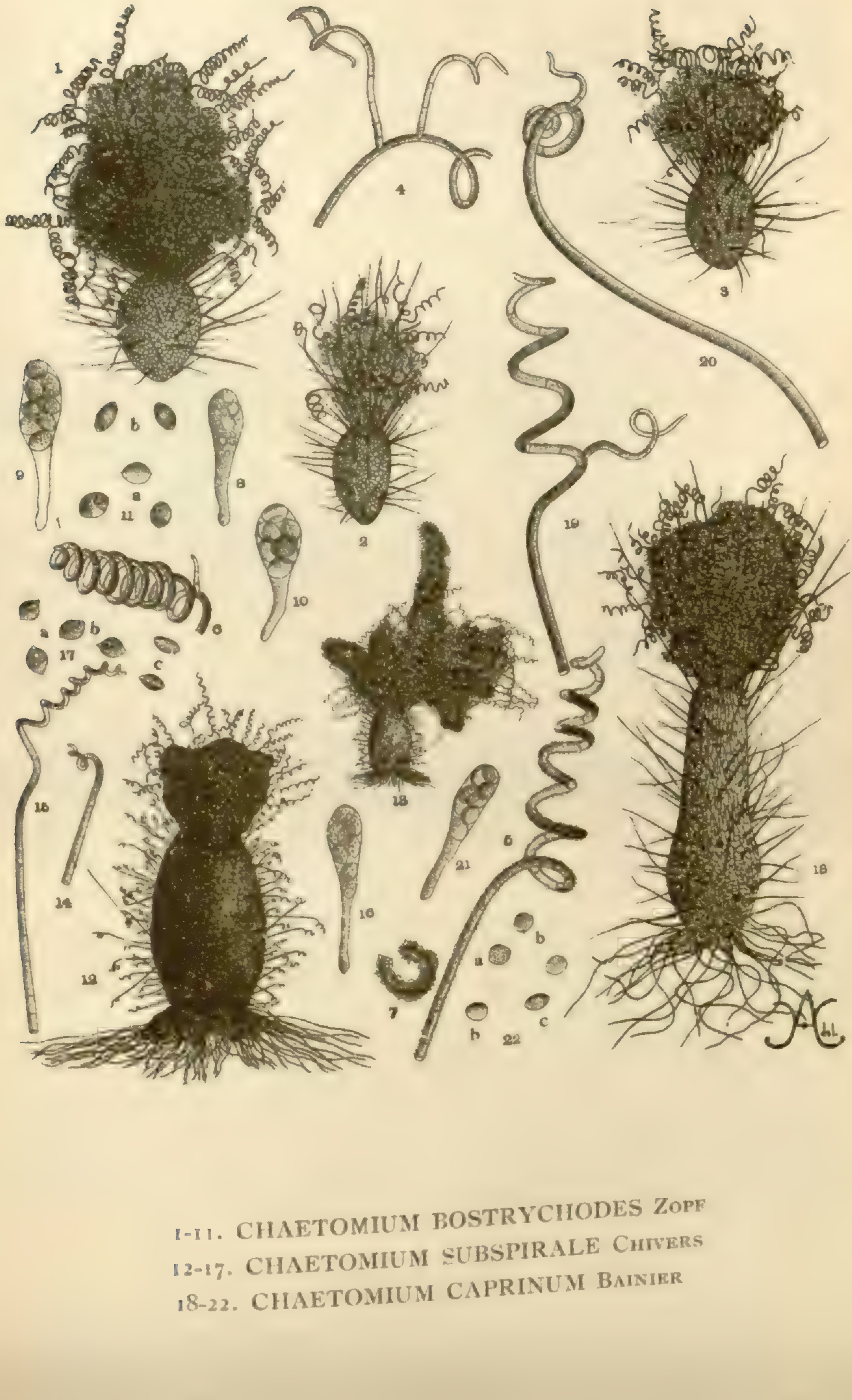

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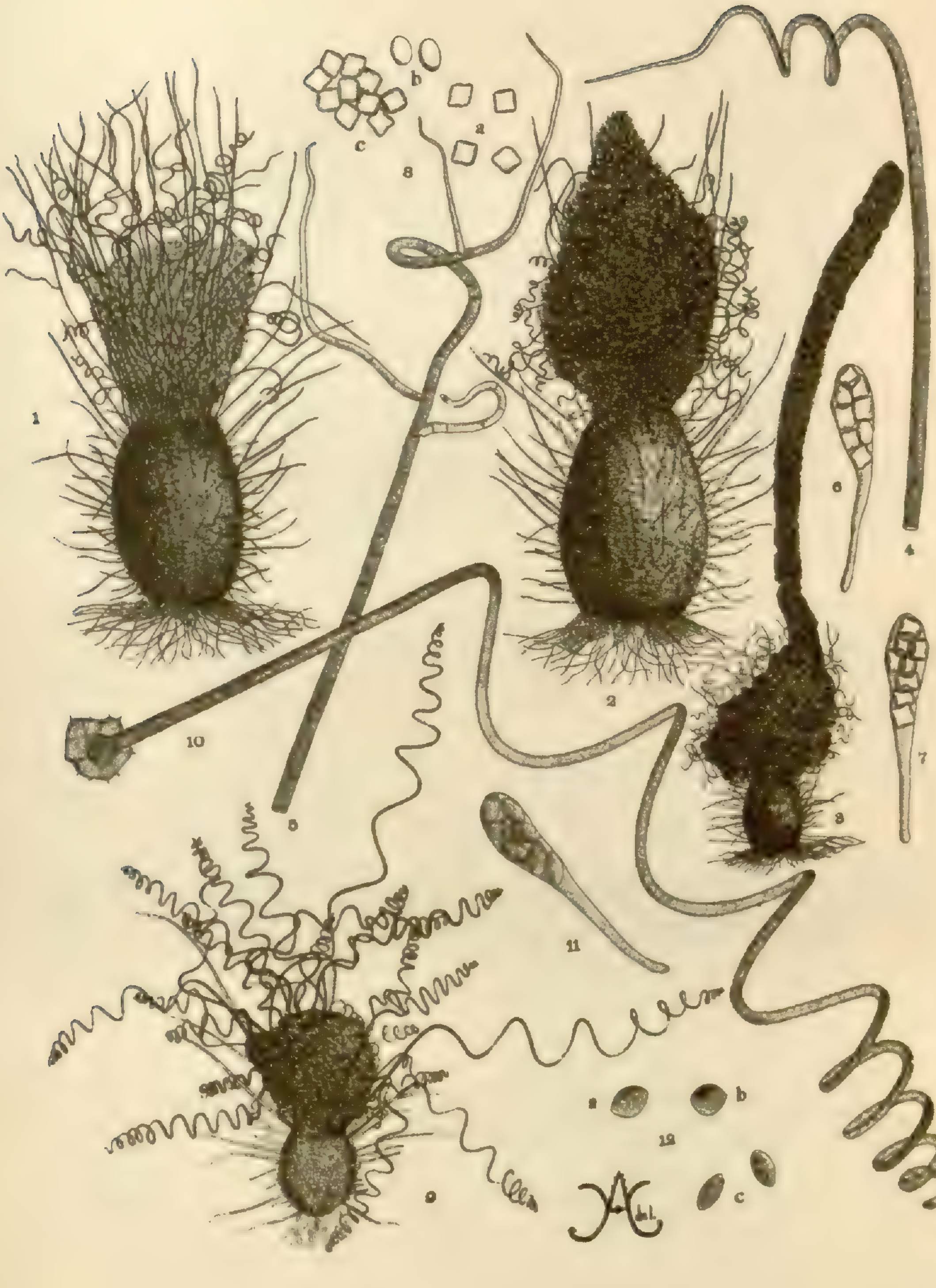

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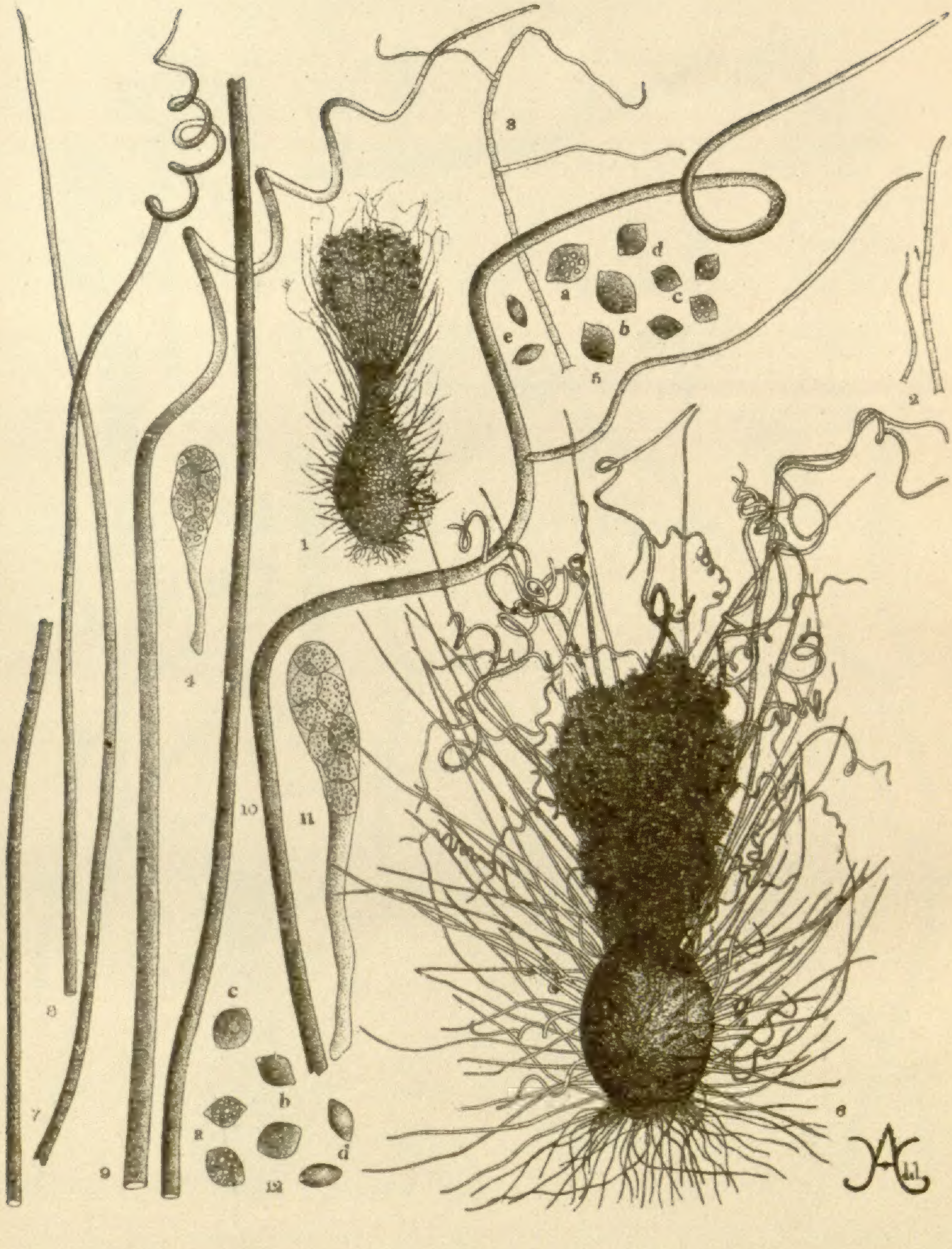

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