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# UNIVERSITY OF IOWA STUDIES IN NATURAL HISTORY

HENRY FREDERICK WICKHAM, Editor

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VOLUME XII

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## CONTENTS

<i>The Iowa Species of Lycoperdon</i> .....	M. L. LOHMAN
<i>The Geasters of Iowa</i> .....	WILLIAM MAYNE LONGNECKER
<i>The Thelephoraceæ of Iowa</i> .....	C. W. EMMONS
<i>Notes on the Tremellales of Iowa, with Keys</i> .....	G. W. MARTIN and EDNA E. HUBER

# THE IOWA SPECIES OF LYCOPERDON

M. L. LOHMAN

## LYCOPERDON Tourn. ex Persoon

Several of the species of this genus are among our most common puffballs although none of them are as conspicuous as the less common larger forms of closely related genera (*Calvatia*, *Bovistella*, and *Mycenastrum*). This genus is probably the largest among the Gasteromycetes in the number of good species described, *Geaster* being its only possible equal. Morgan (4) reported thirty-one species for this country, and Macbride (2) ten species for eastern Iowa. In general, Lycoperdons are quite widespread in their distribution.

The basidiocarp is globose or depressed globose, pyriform, turbinata or broadly turbinate, ranging from 0.8-7 cm. in diameter and about the same in height. The turbinate forms often have an elongate, tapering or rarely subcylindrical base, the base being either continuous, with a cord-like root, or discontinuous, with a fibrous, white mycelium. The coat of the basidiocarp is composed of two layers of peridial, hyphal tissue. The inner peridium (inner layer) is very thin, while the outer peridium (outer layer) is more variable and usually much thicker. The latter is rarely smooth in mature specimens but is usually characteristically marked by warts, spines, fissures, or very minute hairs. The spines are often curved and convergent, and sometimes coherent at the apex, 3.0 mm. or less in length; when shorter usually intermingled with smaller spinules, or with warts; sometimes forming merely a furfuraceous or tomentose coat of minute fibrillose scales or hairlike spinules. In color, the outer peridium is white or whitish when young, later becoming buff, yellowish, or brown, occasionally with a tinge of red or purple; sometimes more or less persistent on the inner peridium but usually dehiscing in part very early. The inner peridium is a thin papery layer, mostly silky and glossy when exposed, pale, light-brown, or brown, and sometimes with a purplish tinge in the purple-spored series. It is persistent and opens by a definite apical mouth which is usually small but becomes 0.5 cm. in diameter with a regular lacerate margin in *L. saccatum*.

The subgleba (sterile tissue) is ordinarily made up of large, coarse, colored cells; rarely of small white compact cells; variable in amount, but usually occupying one-fifth or more of the fruiting body. In several forms the subgleba is obsolete or nearly so, and in a few it is well developed and distinct, but broad and shallow. The subgleba, as a rule, occupies the stemlike base of the obovoid, pyriform, and turbinate fruiting bodies, often being convex above, as a rudimentary columella, and merging gradually with the gleba. The gleba (mass of spores and capillitium) is variable in amount, the threads of the capillitium arising from the inner peridium and from the subgleba. It is white when very young; then (in purple-spored series) olivaceous, later violaceous, and finally purplish-brown at maturity; or (in brown-spored series) greenish-yellow, later olivaceous, and finally brownish-olivaceous or brown at maturity. The capillitium is usually branched, the main threads about the thickness of the spores (in a few forms thicker) mainly pale-brown or dark-brown and only in several species greenish-yellow or hyaline. The basidiospores are found free in the gleba of the mature or nearly mature basidiocarp, being formed and discharged from the basidia while the outer peridium is still white or light colored. (Plate 2; figs. 24-30). The hymenial parts disappear soon after the basidia discharge their spores. In most species with pedicellate spores the sterigma breaks close to the spore. The mature spores are greenish-yellow, brown, or with a tinge of purple; pedicellate in some species; usually globose and rarely oval or elliptical; smooth to extremely warted in the larger spores (sometimes apparently warted under ordinary magnification but smooth under oil immersion, the apparent warts being pores in the thick, smooth, gelatinous wall), 3.5-7.5  $\mu$  in the greater dimension. The basidiocarps are usually terrestrial in open woods, pastures or sandy areas, and occasionally in cultivated fields; in a few species they are lignatile, growing in woods on much decayed wood.

It is believed that the young spores are surrounded by a gelatinous, hyaline layer, probably hymenial remains, for in the maturation of rough-warted spores the warts are at first often completely covered by a thin, gelatinous, hyaline layer, suggesting a spore with a rough-warted endosporium. But careful study (apochromatic objective) reveals the fact that in older spores the warts finally protrude through the gelatinous coat, and that in the case of the mature spore it is distinctly warted and there is no trace of the hyaline



coat left. Occasionally pores are found in warted spores. For example, in *L. rimulatum*, the spores of which are grossly warted, each wart apparently possesses a central pore. In the case of *L. pedicellatum* distinct pores were found in the smooth wall of its spore.

The genus is readily divided into two major groups on the basis of the color of the mature gleba but the distinction is not an easy one to make when working with immature material. Rather closely allied with the purple-spored character of the mature fruiting body is the large size and warted character of the spore. The spores are globose, mostly 5-6  $\mu$  in diameter with *L. rimulatum* having spores 6.5-7.5  $\mu$  in diameter, the largest recorded spores of the genus. The Iowa species of the purple-spored series are *L. asterospermum*, *L. atropurpureum*, *L. elegans*, *L. glabellum*, *L. hirtum*, *L. pulcherrimum*, and *L. rimulatum*. These species are very closely related and apparently quite variable. This has resulted in great confusion in the nomenclature of the group, and Hollós (1) disposes with practically the whole of the purple-spored series in his *L. umbrinum* Pers.—a species with ten varieties.

In the brown-spored series the spores are smaller, being usually less than 5  $\mu$  in diameter. More widely separated forms are included here as the group is easily and naturally subdivided into those forms with a well developed subgleba and those in which the subgleba is either obsolete or nearly so. Further taxonomic characters are made primarily on the peridial characters and the shape of the fruiting body. The Iowa species of the two groups of the brown-spored series are as follows: Subgleba well developed—*L. Curtisii*, *L. gemmatum*, *L. molle*, *L. muscorum*, *L. Peckii*, *L. pedicellatum*, *L. pyriforme*, *L. saccatum*, and *L. separans*: Subgleba obsolete or nearly obsolete—*L. cepæforme*, *L. coloratum*, *L. oblongisporum*, *L. pusillum*, and *L. Wrightii*.

I believe that the division of the genus on the basis of spore characters, as made by Hollós, is not as satisfactory, although it possesses a distinct advantage in the identification of young material where the color of the gleba mass is rather indeterminate. Hollós divides the genus into three groups (a modification of de Toni's system (6) as follows: (1) *Asterosporæ*—spores warted; (2) *Subleiosporæ*—spores very minutely warted; (3) *Leiosporæ*—spores smooth. In my descriptions I have followed Morgan, in general, and have indicated important points in which Morgan and Hollós do not agree. Morgan's treatise on the American forms of *Lycoper-*

*don* in his "Gasteromycetes of North America" is undoubtedly the best work that has been done on the genus in this country.

A study of our collections, which include a number of interesting forms from the sand hills of Muscatine and Louisa counties, made it evident that the study of the Iowa species had been inadequate and that we had several species among our collections which had not been reported from Iowa in the literature to date.

The following species were reported by Macbride and Allin: *L. asterospermum*, *L. atropurpureum*, *L. elegans*, *L. gemmatum*, *L. molle*, *L. Peckii*, *L. pedicellatum*, *L. pulcherrimum*, *L. pusillum*, and *L. pyriforme*. Of these ten species *L. elegans* and *L. Peckii* were not among our collections. The following species new to Iowa were among our collections: *L. cepaforme*, *L. coloratum*, *L. Curtisii*, *L. glabellum*, *L. hirtum*, *L. muscorum*, *L. oblongisporum*, *L. rimulatum*, *L. saccatum*, *L. separans*, and *L. Wrightii*. Of these twenty-one species all were recognized by Morgan except *L. saccatum*. In addition to these, *L. echinatum*, *L. subincarnatum*, and *L. Turneri* have been reported from Wisconsin (Morgan) and it is quite probable that they occur in Iowa. Important characteristics of each (from Morgan's descriptions) are given in connection with the description of the closely related species included in this work, *L. pulcherrimum*, *L. pyriforme*, and *L. muscorum*, respectively.

In the following descriptions color terms pertaining to peridial or gleba characters are in parentheses, and are those of Ridgeway (5). In the collection data following each description the month refers to the time of collection and is not to be interpreted to mean the time of year when these particular species are to be found.

This is a part of a series of studies on the Gasteromycetes being carried on at the State University of Iowa under the direction of Prof. G. W. Martin.

#### KEY TO THE SPECIES OF LYCOPERDON

1. Mass of spores and capillitium at first olivaceous; then violaceous; finally purplish-brown at maturity; spores globose, distinctly warted, mostly 5-6  $\mu$  in diameter; in *L. rimulatum* 6.5-7.6  $\mu$ .....2
1. Mass of spores and capillitium at first greenish-yellow; then olivaceous; finally brownish-olivaceous or brown at maturity; spores smooth or minutely warted, globose and mostly less than 5  $\mu$  in diameter; oval with long pedicels, (*L. pedicellatum*); or elliptic, (*L. oblongisporum*).....8
2. Outer peridium of long white slender curved and convergent spines, the upper ones 2-3 mm. in length; basidiocarp obovoid with a thick cord-like root.....(1) *L. pulcherrimum*

2. Outer peridium otherwise.....3
3. Outer peridium a thin smooth layer becoming rimulose, then appressed scaly; spores 6.5-7.5  $\mu$  with large warts.....(2) *L. rimulatum*
3. Outer peridium a coat of shorter spines, convergent or simple, or simply furfuraceous .....4
4. Outer peridium of slender spines 0.5 mm. or less in length, convergent or simple, or with intermingled granules.....5
4. Outer peridium a white or yellowish flocculose coat; later brown furfuraceous; persistent.....7
5. Basidiocarp turbinate or broadly turbinate with a thick cord-like root.....(3) *L. hirtum*
5. Basidiocarp subglobose, obovoid, or pyriform; with a fibrous mycelium....6
6. Basidiocarp obovoid or pyriform; outer peridium a thin coat of minute spines with intermingled granules.....(4) *L. asterospermum*
6. Basidiocarp subglobose, rarely obovoid or pyriform; outer peridium a dense coat of slender, hair-like, mostly convergent spines, the upper ones 0.5 mm. or less in length.....(5) *atropurpureum*
7. Basidiocarp large, 3.5-7 cm. in diameter; depressed globose, with a thick cord-like root.....(6) *L. elegans*
7. Basidiocarp smaller, 2-4 cm. in diameter; obovoid or turbinate, with a fibrous mycelium.....(7) *L. glabellum*
8. Subgleba well developed, usually obconical, occupying the stem-like base, but in more flattened forms often broad and shallow; usually one-fifth or more of the basidiocarp.....9
8. Subgleba obsolete or nearly so.....17
9. Outer peridium of long, curved and convergent spines, the upper ones about 1 mm. in length; sometimes with intermingled smaller spines.....10
9. Outer peridium of shorter spines or thick terete warts (the upper ones about 0.5 mm. in length), with intermingled spines; or simply furfuraceous .....13
10. White stout convergent spines falling away in large plates or patches; basidiocarp with a cord-like root.....(8) *L. separans*
10. Spines falling away separately; basidiocarp with a fibrous mycelium.....11
11. Inner peridium smooth; spores with minute pedicels or non-pedicellate....12
11. Inner peridium more or less reticulate, wrinkled or obscurely pitted; spores with long persistent pedicels.....(9) *L. pedicellatum*
12. Threads of capillitium hyaline or pale yellow, 2-3 times as thick as spores; spores globose, 3.5-4  $\mu$  in diameter.....(10) *L. Curtisi*
12. Threads of capillitium mostly thinner than spores; spores globose, 4-5  $\mu$  in diameter.....(11) *L. Peckii*
13. Outer peridium of stout spines or warts falling away and leaving a white-spotted reticulate appearance.....(12) *L. gemmatum*
13. Outer peridium otherwise.....14
14. Basidiocarps mostly lignatile; subgleba white, of small cells; spores smooth, 3.5-4.5  $\mu$  in diameter.....(13) *L. pyriforme*
14. Basidiocarps mostly terrestrial; subgleba usually coarser and of larger cells, not white; spores warted.....15

15. Basidiocarp large, broadly turbinate with thick tapering or cylindrical base 1-2.5 cm. in diameter; spores 4.5-5.5  $\mu$  in diameter....(14) *L. saccatum*
15. Basidiocarp usually smaller with a much smaller base; spores somewhat smaller .....16
16. Outer peridium a soft coat of minute spines with intermingled granules; spores 4-5  $\mu$  in diameter.....(15) *L. muscorum*
16. Outer peridium a minute, persistent, mealy furfuraceous coat; spores 3.5-4.5  $\mu$  in diameter.....(16) *L. molle*
17. Spores globose, smooth or minutely warted.....18
17. Spores elliptical, smooth, 3.5-4.5 by 5-6  $\mu$ .....(17) *L. oblongisporum*
18. Spores minutely warted, 3.5-4.5  $\mu$  in diameter; subgleba obsolete.....19
18. Spores smooth, 3.5-4.5  $\mu$  in diameter; subgleba nearly obsolete.....20
19. Outer peridium a mealy furfuraceous coat; basidiocarp with a slender cord-like root.....(18) *L. pusillum*
19. Outer peridium a fibrillose-spinulose coat; basidiocarp with a fibrous mycelium.....(19) *L. Wrightii*
20. Outer peridium a minutely furfuraceous coat becoming rimulose; basidiocarp with a cord-like root.....(20) *L. cepaforme*
20. Outer peridium a thin coat of minute persistent granules; basidiocarp with a fibrous mycelium.....(21) *L. coloratum*

### 1. *L. pulcherrimum* B. and C.

Basidiocarp obovoid, somewhat depressed above, 2-3 cm. in diameter, plicate beneath, with a thick cord-like root; outer peridium of slender white dehiscient spines, the upper one 2-3 mm. in length and the lower ones smaller, curved and convergent at the apex, often coherent, the upper ones falling first, leaving a cinnamon-brown, mealy, or minutely granular coat, later dehiscient also, exposing the smooth, reddish-brown or purplish-brown inner peridium; subgleba broad and shallow, neither compact, nor definitely limited above; gleba cinnamon-buff to cinnamon-brown, later becoming brownish-purple; capillitium threads much branched, the main ones about as thick as the spores; spores globose, distinctly warted, averaging 5  $\mu$  in diameter. (Plate I, fig. 1).

On ground in woods. Iowa City, October. Reported from Kansas, Iowa, Wisconsin, and eastward.

Morgan describes this species as 2-6 cm. in diameter and 2-5 cm. high. As the specimens at hand were immature the characters given for the mature fruiting body are taken from Morgan's description. The long, shaggy spines of the outer peridium are the distinguishing character.

*L. echinatum* Pers., reported from Wisconsin but not among our Iowa collections, differs from this species in that the basidiocarp is broadly obovoid, sometimes much depressed, 2-3.5 cm. in diameter,

with a mycelium of long slender white fibers; outer peridium of very long (3 mm.) brown spines, curved and convergent at the apex, often coherent, dehiscing, leaving dark-brown reticulations formed by minute spinules on the pale-brown inner peridium. When the minute spinules dehiscence the inner peridium is left smooth.

### 2. *L. rimulatum* Peck

Basidiocarp depressed globose, sessile, 1.5-2.5 cm. in diameter and 1-1.5 cm. high, plicate beneath with a fibrous mycelium; outer peridium a smooth thin layer soon becoming rimulose, later breaking up into purplish-brown, thin, appressed, dehiscent scales, the upper ones disappearing first, exposing the smooth, pale, inner peridium; subgleba broad, occupying about one-fourth of the fruiting body, or very shallow and nearly obsolete, the cells rather large; gleba at first light colored with a tinge of purple, later varying toward brown (burnt umber); capillitium threads little branched, the main ones thinner than the spores; spores globose, 6.5-7.5  $\mu$  in diameter, distinctly warted, the warts large and hyaline with a central pore apparent at a magnification of 900 diameters. (Plate I, fig. 2).

On open ground in sandy hills, Muscatine County, north of Bayfield, November. Reported from New York, South Carolina, Ohio and Wisconsin.

Spore measurements as reported are variable—Morgan 6-7  $\mu$ ; Hollós 5-6 $\mu$ ; and Trelease (according to Hollós) 5-6.5  $\mu$ .

### 3. *L. hirtum* Mart.

Basidiocarp turbinate or broadly turbinate, depressed above, 2.5 cm. broad and 4 cm. high, contracted below into a short thick, tapering, stem-like base with a cord-like root; outer peridium a dense coat of slender, soft, dehiscent, brown, convergent spines, the upper ones 0.5 mm. or less in length, falling away first, exposing the smooth, glossy, pale or purplish-brown surface of the inner peridium, the lower ones shorter and more scattered with patches of intermingled granules; subgleba of large cells, occupying little more than the stem-like base, one-third to one-half of the fruiting body; gleba at first olivaceous, then brownish-purple (bister to burnt umber); capillitium threads considerably branched, the main ones about as thick as the spores, the branches slender or tapering; spores globose, distinctly warted, surrounded by a thin, hyaline, gelatinous layer, apparent at a magnification of 900 diameters, 5-6  $\mu$  in diameter, averaging less than 5.5  $\mu$ . (Plate I, fig. 3).

On ground in woods. Iowa City, September.

Morgan describes the basidiocarp as 2-6 cm. in diameter and 4-5 cm. high. The characteristics given above for the mature fruiting body are as given by Morgan since the material at hand was an immature lot. He has followed Masee in keeping this species separate from *L. atropurpureum*. Hollós regards this as a synonym for *L. umbrinum* Pers., a species under which he describes ten varieties.

#### 4. *L. asterospermum* Dur. and Mont.

Basidiocarp obovoid or pyriform, 1.5-4 cm. in diameter, a little higher than broad, the base short, pointed, occasionally plicate, with a fibrous mycelium; outer peridium a thin coat of minute spines with intermingled granules, minutely scabrous, gray or brownish, quite persistent but finally dehiscing, exposing the smooth, glossy, pale-brown (natal brown to vinaceous or Hay's brown) surface of the inner peridium; subgleba occupying about a third of the fruiting body, of large cells, gradually merging with the gleba above; gleba at first olive-brown, finally brownish-purple; capillitium threads branched, the main ones about as thick as the spores; spores globose, distinctly warted, sometimes nearly bluntly echinulate, 5-6  $\mu$  in diameter, averaging more than 5.5  $\mu$ . (Plate I, fig. 4).

On ground in rather open woods. Iowa City, September and November. Reported from Ohio, Iowa and Nebraska.

Morgan records spores as 5.5-6.5  $\mu$  in diameter. This is *L. umbrinum* Pers. var. *asterospermum* Dur. and Mont. of Hollós.

#### 5. *L. atropurpureum* Vitt.

Basidiocarp subglobose, rarely obovoid or turbinate, 2-5 cm. in diameter, plicate beneath, with a fibrous mycelium, the larger fruiting bodies often very irregular with a thick, plicate, and lacunose base; outer peridium a dense coat of slender hair-like, dehiscent spines, curved and convergent at the apex, the upper ones gray or brownish, often becoming reddish-brown at maturity, 0.5 mm. or less in length, falling away first, exposing the smooth, glossy, pale or pale-brown (buckthorn brown) surface of the inner peridium, the lower ones smaller, and lighter, subgleba broad and shallow, occupying about one-third of the fruiting body; gleba at first olive-brown, finally brownish-purple (Hay's brown or dark vinaceous brown); capillitium threads branched, dark brown, the main ones about as thick as the spores; spores globose, distinctly warted, 5-6  $\mu$  in diameter. (Plate I, fig. 5).

On sandy ground. Muscatine County, Bayfield, April. On ground in woods. Iowa City, September. Reported from Iowa, Wisconsin, and eastward.

According to Morgan this form is subglobose with an outer peridium of soft white or yellowish slender spines or hairs; the subgleba sometimes nearly obsolete. The forms described above are more in accord with Hollós' description. This is *L. umbrinum* Pers. var. *atropurpureum* Vitt. of Hollós, which may be globose or pyriform with a short, thick, tapering stem-like base, and an outer peridium of slender spines or hairs, the upper ones gray or brown and convergent, the lower ones yellowish.

From the varieties of this form as originally reported by Vittadini, and from the ten varieties described by Hollós under *L. umbrinum* Pers., it is evident that these purple-spored forms are very closely related. The species as described in the literature are very variable and intergrade, the microscopic characters being practically the same for all. A number of forms were collected north of Bayfield, Muscatine County, growing caespitously in the sand, which showed extreme variation from *L. atropurpureum* Vitt. as described by Morgan. They were more in accord with Hollós' description of this form. The outstanding characters not in accord with Morgan's description were the broadly turbinate shape of the fruiting bodies, which were mostly 1-2 cm. in diameter; the soft, gray, or pale-brown, persistent, tomentose or furfuraceous coat on the surface of the inner peridium after the dehiscence of the spines; the well-developed subgleba; and the very minutely warted spores, 5.6-6.5  $\mu$  in diameter.

The ecology of the fungi of the region where these forms were collected is extremely interesting and greatly in need of critical study.

#### 6. *L. elegans* Morg.

Basidiocarp large, depressed globose, 3.5-7 cm. in diameter, plicate beneath, sometimes with a narrow umboniform base, the base continuous with the thick root; outer peridium at first flocculose, white or yellowish, drying, forming a dense furfuraceous, persistent, ochraceous or brownish coat, sometimes obscurely areolate; subgleba broad, convex above, occupying a third or more of the fruiting body; gleba olivaceous, finally pale-brown or purplish-brown; capillitium threads much branched, the main ones thicker than the spores, the

branches long and tapering; spores globose, distinctly warted, 5-6  $\mu$  in diameter.

On rich soil of the open prairie about Iowa City; (Macbride).

This species was described by Morgan from a specimen collected in Muscatine county, and other specimens were collected several years later by Prof. T. H. Macbride, confirming it. The characters given above are taken from Morgan's description of the species as the original specimens were not available, and no other collections have been reported.

#### 7. *L. glabellum* Peck

Basidiocarp obovoid with a short, pointed base, or turbinate with a narrow, tapering, or nearly cylindrical base, 2-4 cm. in diameter, of about the same height, with slender fibrous mycelium; outer peridium a soft, dense, yellowish, flocculose coat, later drying, becoming brown, furfuraceous and somewhat granular, slightly rimulose above, more or less persistent, the light brown, smooth, glossy surface of the inner peridium only exposed in a few scattered patches and irregular marks; subgleba occupying the stem-like base, about one-third of the fruiting body, paler than the gleba, with a tinge of purple; gleba pale-olivaceous, later becoming dark-brown or purplish-brown (dark vinaceous brown or Hay's brown); capillitium threads little branched, the main ones about as thick as the spores; spores globose, 5-6  $\mu$  in diameter, rough warted, the warts nearly hyaline, surrounded by a thin, gelatinous, hyaline layer, less evident at maturity, the warts finally protruding, becoming more distinct. (Plate I, fig. 6).

On ground in woods. Johnson County: North Liberty, September. Reported from Wisconsin, Ohio, New York, and the New England states.

This is *L. umbrinum* Pers. var. *glabellum* Peck. of Hollós. Morgan says of it, "A beautiful species, regular in form, soft to the touch, and attractive in color."

#### 8. *L. separans* Peck

Basidiocarp subglobose to broadly obovoid, often much depressed, 2-5 cm. in diameter and 1-4 cm. high, plicate beneath, often with a short, thick, tapering, stem-like base, continuous with the cord-like root; outer peridium a dense, thick coat of white, stout spines, the upper ones longest, about 1 mm. in length, convergent at the apex, pale, brown, or reddish-brown at maturity, dehiscant in large flakes



or patches, the upper ones disappearing first the patches often free from the inner peridium but not dehiscent, in either case leaving a pale or dark-brown (dark olive buff to Rood's brown), thin, furfuraceous or tomentose, gradually dehiscent layer on the glossy, finally exposed surface of the inner peridium; subgleba broad, occupying one-third to one-half of the fruiting body, definitely limited above; gleba pale- (light brownish olive) to dark-brown (snuff brown or Saccardo's umber); capillitium threads branched, variable in thickness but some thicker than the spores; spores globose, smooth, or occasionally minutely warted, 3.5-4  $\mu$  in diameter, with a short pedicel. (Plate I, figs. 7, 8).

On ground in woods. Johnson County: Mid River, June; North Liberty, August; Iowa City, August and September. On sandy ground. Muscatine County: Bayfield, November. Reported from Wisconsin and eastward.

This is *L. separans* Peck. in the sense of Morgan, and Hollós includes this form with several, which he claims to be synonymous, under *L. papillatum* Schæff. (described by Schæffer in 1763). Both Hollós and Morgan describe the spores as smooth, but two specimens were found at North Liberty (2.5-3 cm. broad and 1.5-2 cm. high) which were identical with our other collections of *L. separans* except that the spores were slightly roughened with minute, sharp, scattered warts, nearly echinulate. The spores were 3.5-4  $\mu$  in diameter, which, together with the flaking off of the outer peridium and the extremely subglobose fruiting body, would keep these specimens from *L. excipuliforme*. Possibly they should not be referred to *L. separans* until further collection and study, but there is no reason why *L. separans* could not have minutely warted spores, as well as *L. gemmatum*.

#### 9. *L. pedicellatum* Peck

Basidiocarp obovoid, or turbinate, 2-3 cm. in diameter, 3-4 cm. high, with a short, thick, tapering base and a fibrous mycelium; outer peridium of stout, mostly dehiscent spines, about 1 mm. in length, circularly arranged, curved and convergent at the apex, yellowish at first, becoming brown, the upper ones falling first leaving scabrous reticulations on the at first pale and smooth, but finally wrinkled or obscurely shallow-pitted surface of the inner peridium, the lower spines quite persistent; subgleba compact, cupulate-convex, definitely limited above, occupying little more than the stem-like base; gleba at first greenish-yellow, then pale-olivaceous or

cinnamon-buff (cinnamon buff or clay color) becoming brownish when older (Brussel's brown or raw umber); capillitium threads branched, the main ones thicker than the spores; spores globose or slightly oval, smooth, sometimes apparently minutely warted at ordinary magnification, but at a magnification of 900 diameters distinctly smooth, the gelatinous wall containing cylindrical pores, 3.5-4.5 by 4-5  $\mu$ , with hyaline persistent pedicels averaging 25  $\mu$  in length. (Plate I, figs. 9, 10).

On ground and on greatly decayed wood in woods. Iowa County: Homestead, April. Johnson County: Mid River, October. Reported from Iowa, Wisconsin and eastward; also from Alabama.

The specimens collected in April were mature and quite weathered and it may be that they were from the preceding autumn. Morgan reports the fruiting body as attaining slightly greater diameter, and Hollós records the species as 1.5-4 cm. in diameter. These forms are unmistakable in their long, hyaline, persistent pedicels. One specimen which I collected in Butler County, Ohio, September, 1926, had pedicels averaging 30  $\mu$  in length, some of them measuring 45  $\mu$ .

#### 10. *L. Curtisii* Berk.

Basidioecarp globose or depressed globose, 1-2 cm. in diameter, with a very short rooting base and a fibrous mycelium; outer peridium a soft, white or yellowish coat of rather stout, dehiscent spines, the upper ones about 1.0 mm. in length, curved at the tip and sometimes convergent, with intermingled smaller spines and furfuraceous scales, the lower spines smaller, dehiscent after maturity, usually by the spines falling away separately in scattered and irregular patches, exposing the pale, smooth surface of the inner peridium; subgleba small but distinct, occupying the root-like stem, convex and definitely limited above; gleba at first greenish-yellow, then pale olivaceous (deep to dark olive buff); capillitium threads long, simple or sometimes sparingly branched, hyaline or pale-yellow, mostly two to three times the thickness of the spores; spores globose, smooth, or very minutely warted at a magnification of 900 diameters, 3.5-4  $\mu$  in diameter, sometimes with a minute pedicel. (Plate I, fig. 11).

On sandy ground. Muscatine County: Bayfield, November. On ground in lawn, gregarious and caespitose. Iowa City, September. Reported from Kansas, Wisconsin, and eastward.

Morgan says of this species, "Growing gregariously, and caespitously, on the ground in meadows, pastures, and even in cultivated

fields." An unmistakable character of the species is the large, hyaline or little colored capillitium. This is *L. Wrightii* var. *typicum* Peck, which Hollós regards as a small globose, sessile form of *L. hyemale* (Bull. p.p.) emend. Vitt. Vittadini redescribed this particular part of Bulliard's *L. hyemale* and gave it the same name. Thus to agree with Vittadini the name would be *L. hyemale* Vitt. This as described by Hollós includes a wide variety of forms and it seems best to follow Morgan here in recognizing *L. Curtisii* Berk.

#### 11. *L. Peckii* Morg.

Basidiocarp obovoid, 2.5-4 cm. in diameter, with a slender fibrous mycelium; outer peridium whitish, ochraceous, or brownish, sometimes with a reddish tinge, composed of long, finally dehiscent spines, usually curved and convergent at the apex, the surface of the inner peridium pale and smooth when finally exposed; subgleba scarcely a third of the fruiting body; gleba at first greenish-yellow, then brownish-olivaceous; capillitium threads scarcely branched, somewhat thinner than the spores; spores globose, minutely warted, 4-5  $\mu$  in diameter.

On ground or on decaying wood in woods. Reported from Iowa and eastward; also from Alabama.

Of this species Macbride says, "This is a common little species on the ground in thinly covered meadows and pastures." Among our collections there was but one which had been determined as this species, and on restudy this was found to be a collection of young specimens of *L. pulcherrimum*. As the original specimens are not available, the above is based on Morgan's description of the species.

#### 12. *L. gemmatum* Batsch.

Basidiocarp turbinate, 1-4.5 cm. in diameter and 1.5-7 cm. high; somewhat depressed above, the base short, obconical or more elongate, tapering or nearly cylindrical, with a fibrous mycelium; outer peridium of dehiscent stout spines or thick pyramidal warts, with intermingled smaller soft spines, all whitish or gray at first, later yellowish, sometimes brown or reddish-brown, the upper thick spines or warts 0.5 mm. or less in diameter, falling first, leaving the surface white spotted and usually with a reticulate appearance, the lower ones smaller and more scattered; subgleba of large cells, occupying the stem-like base, about half of the fruiting body, convex above and merging gradually with the gleba, usually brownish with a tinge of purple; gleba at first greenish-yellow, finally pale-brown (buffy

olive to snuff brown or bister); capillitium threads little branched and sometimes simple, about the thickness of the spores; spores globose, smooth, or very minutely warted, 3.5-4.5  $\mu$  in diameter. (Plate I, figs. 12, 13).

On ground. Dubuque County: Cascade, August. Dickinson County: West Okoboji, July and August. Johnson County: Coralville, April and August; Cou Falls, August; Iowa City, July to October. On greatly decayed wood. Iowa City, April and October; North Liberty, October. Often caespitose. Reported from Kansas, Iowa, Wisconsin, and eastward; also from California.

Morgan says of this form, "This species is distinguished from all others by the peculiar large erect terete spines or warts, the so-called gems which stud its upper surface." The whitish spots and reticulate surface after the dehiscence of the large thick spines are just as characteristic. This is the most common species of the genus about Iowa City.

### 13. *L. pyriforme* Schæff.

Basidiocarp obovoid or pyriform, 1.5-3 cm. in diameter and 2-5 cm. high, with abundant white fibrous mycelium; outer peridium a thin, persistent coat of minute furfuraceous scales, or of granules, or short spinules, whitish-gray or brownish (Sayal brown), later dark-brown or reddish-brown (pecan brown to Rood's brown). Often areolate, in finely areolate forms sometimes squamulose; subgleba less than the stem-like base, white, of compact small cells; gleba greenish-yellow (Isabella color), later brownish-olivaceous (light brownish olive or buffy olive); capillitium threads branched, the main ones thicker than the spores; spores globose, smooth, 3.5-4.5  $\mu$  in diameter. (Plate I, fig. 14).

On old timber. Johnson County: North Liberty, October; Iowa City, September to November. On ground at foot of maple tree, Iowa City, October. Usually caespitose, often forming dense clusters. Reported from Kansas, Iowa, Wisconsin, and eastward; also from California.

The distinguishing characters are its usually caespitose and lignatile habit; its shape; and the size and color of the subgleba. *L. subincarnatum* Peck, reported from Wisconsin, but not among our Iowa collections, differs from this species in the globose, sessile basidiocarp, 2-3.5 cm. in diameter, with an outer peridium of minute, short, stout spinules, dehiscent at maturity, leaving the surface of the inner peridium deeply pitted; the threads of the capillitium

long, simple, hyaline; the spores globose, minutely warted, 4-4.5  $\mu$  in diameter. It is also lignatile in habit.

14. *L. saccatum* Vahl.

Basidiocarp turbinate, 2.5-4 cm. in diameter, opening by a definite apical pore, about 0.5 mm. in diameter, with a regularly lacerate margin, base stem-like, long, thick, tapering or nearly cylindrical, plicate and somewhat lacunose in larger forms, 1-2.5 cm. in diameter, with a slender fibrous mycelium; outer peridium light brown above (snuff brown), of minute fibrillose spinules or furfuraceous scales, with small, numerous, intermingled granules; darker below (clay brown), of furfuraceous scales with fewer and larger intermingled granules, all more or less persistent, only revealing the smooth, pale inner peridium in small, scattered patches; subgleba large but occupying little more than the stem-like base, convex above, gradually merging with the gleba; gleba at first greenish-yellow, then brownish-olivaceous; capillitium arising from the inner peridium and subgleba, the threads dark-brown and very much branched, the main ones thicker than the spores, the branches long and tapering; spores globose, 4.5-5.5  $\mu$  in diameter, often with a short pedicel, minutely warted to distinctly warted and nearly echinulate, at a magnification of 900 diameters apparently surrounded by a thin gelatinous layer. (Plate I, fig. 15).

On ground. Muscatine County: November.

This is probably *L. elatum* as described by Masee. He believed that species to be an American form of *L. saccatum*. Morgan places both in the genus *Calvatia*. Of *C. saccata* he says, "This species has been reported from North America by various authorities but I have never seen any American specimens." (3) There should be no hesitation in placing the specimens in our collections in the genus *Lycoperdon* for the dehiscence alone makes them anything but *Calvatias*, and *Calvatia* is the only other genus suggested by the color, size, and shape of the fruiting body. The spores both from those forms with tapering and those with cylindrical bases measured 4.5-5.5  $\mu$ , which is the average of the spore measurements given by Morgan for *C. saccata* (5-6  $\mu$ ) and *S. elata* (4-5  $\mu$ ). From the study of our specimens it seems needless to separate the tapering forms as a distinct species and they have been included in *L. saccatum*.

15. *L. muscorum* Morg.

Basidiocarp turbinate or broadly obovoid, globose or depressed

globose above, contracted below, 1-3 cm. broad and 1.5-6 cm. high, the base tapering, stem-like, with a fibrous mycelium; outer peridium a rather soft, more or less persistent coat of minute spines and intermingled granules, the upper granules larger and scattered, sometimes nearly furfuraceous, at first white, later yellowish (olive ochre to clay color), sometimes with a reddish tinge (russet vinaceous), the smooth surface of the inner peridium, when exposed, pale or olive-brown (buffy brown to olive brown); subgleba little more than the stem-like base, usually one-third to one half of the fruiting body; gleba at first greenish yellow, later olive brown (clay color or light brownish olive) to brown (snuff brown or Saccardo's umber); capillitium threads little branched, the main ones as thick as, or slightly thicker than the spores; spores globose, minutely warted, 4-5  $\mu$  in diameter, averaging less than 4.5  $\mu$ . (Plate I, fig. 16).

On sandy ground. Muscatine County: Bayfield, November. Among mosses on ground in woods. Iowa City, September and October. Reported from New York and Virginia. I have recently collected this species in Ohio.

Hollós describes the basidiocarp as 1.2-3.3 cm. broad and 2.5-7.5 cm. high. This form is *L. molle* Pers. of Peck, and Morgan makes it a new species which Hollós recognizes. Of this Morgan says, "Growing among mosses, especially *Polytrichum*, in old meadows and pastures." From our collections it is evident that moss is not an essential habitat.

*L. Turneri* E. and E., reported from Wisconsin but not among our Iowa collections, differs from this species in that the basidiocarp is obovoid, depressed above, plicate beneath, 2.5-5 cm. in diameter and of about the same height; the spores are globose, minutely warted, 4-5  $\mu$  in diameter, mostly with a short pedicel.

#### 16. *L. molle* Pers.

Basidiocarp broadly turbinate to turbinate, 1.5-4 cm. in diameter and of about the same height, abruptly contracted below, the base short, thick, tapering, stem-like, with a fibrous mycelium; outer peridium a rather persistent, mealy-furfuraceous coat, evident with the aid of a hand lens when apparently smooth to the naked eye, white or yellowish, later becoming darker (olive ochre to buffy brown or snuff brown), the pale, smooth, olive-brown surface of the inner peridium finally exposed in scattered patches from above downward; subgleba obconical, coarse, convex above, little more

than the stem-like base, usually one-third to one-half of the fruiting body, gradually merging with the gleba above; gleba at first greenish-yellow, later pale-brown (Isabella color) or brownish-olivaceous (buffy olive); capillitium threads branched, the main ones about as thick as the spores; spores globose, minutely warted, 3.5-4.5  $\mu$  in diameter, often with a minute pedicel. (Plate I, fig. 17).

On ground in woods. Iowa City, October. Reported from Wisconsin and Iowa.

Macbride says of this species, "It is the smoothest turbinate species we have. In wet weather the inner peridium has a tendency to crack in areas." However, this species very closely resembles small forms of *L. glabellum* and the spore characters are the only good distinguishing marks.

#### 17. *L. oblongisporum* B. and C.

Basidiocarp subglobose, 1-2.5 cm. in diameter, with a slender, rooting, mycelial cord; outer peridium a thin persistent coat, at first whitish or yellowish, furfuraceous, later drying up, becoming brown or reddish-brown, thin, scattered, granular or fibrillose-scaly, the surface of the inner peridium smooth, shining, brown (walnut or snuff brown); subgleba nearly obsolete; gleba greenish-yellow, then pale- (cinnamon or snuff brown) to dark-brown (Prout's brown or bister); capillitium threads long and much branched, the main ones thicker than the spores; spores smooth, elliptical, 3.5-4.5 by 5-6  $\mu$ , often with a minute pedicel. (Plate I, fig. 18).

On ground in dense woods. Dickinson County: West Okoboji, August. Johnson County: North Liberty, August; Cou Falls, October. Reported from Wisconsin.

Morgan describes the outer peridium of the mature fruiting body as "minute persistent granules on the pale-brown surface of the inner peridium." The spores are the distinguishing character of the species, and according to Morgan it is difficult to distinguish immature specimens from those of *L. pusillum*. Hollós reports European forms of this as 0.9-2.5 cm. in diameter.

#### 18. *L. pusillum* Batsch.

Basidiocarp globose, sessile, 1-2 cm. in diameter, somewhat plicate beneath, with a slender, cord-like root; outer peridium a whitish, mealy, furfuraceous coat, the scattered minute brownish squamules persistent on the pale-brown inner peridium; subgleba obsolete; gleba light-olivaceous or brownish (buffy citrine to Isabella brown)

at maturity; capillitium threads much branched, irregular and variable in thickness, the main ones somewhat thicker than the spores; spores globose, minutely but distinctly warted, 3.5-4  $\mu$  in diameter. (Plate II, fig. 19).

On ground. Louisa County: Big Mound, November. Reported from Kansas, Iowa, Wisconsin, and eastward.

This form differs from Morgan's description in the slightly thicker threads of the capillitium and the minutely warted spores. Morgan describes the spores as "globose, even, 3.5-4  $\mu$  in diameter, often with a minute pedicel." This form according to Hollós is quite common in Europe—"growing on ground in open woods, meadows, or sandy fields, 9-18 mm. in diameter; spores smooth, except at a magnification of 1000 diameters, or in dry mount at a magnification of 750 diameters, when they are minutely warted."

#### 19. *L. Wrightii* B. and C.

Basidiocarp globose, sessile, about 12 mm. in diameter and 10 mm. in height, with a fibrous mycelium; outer peridium fibrillose-spinulose, the fibrillose spines occasionally convergent, with furfuraceous patches, whitish and quite persistent on the pale-brown inner peridium; subgleba obsolete; gleba brownish-olivaceous (Isabella color) at maturity; capillitium threads sparingly branched, the main ones about as thick as the spores, the branches tapering; spores globose, 3.5-4.5  $\mu$  in diameter, minutely warted but some apparently smooth, when warted the warts distinct but scattered. (Plate II, fig. 20).

On ground. Louisa County: Big Mound, November. Reported from eastern U. S.

Morgan describes the fruiting body as 12-20 mm. in diameter. Three specimens were collected in the sandy area north of Bayfield, Muscatine County, and they differed in that the basidiocarps were very small (mature specimens 8-10 mm. in diameter), and the spores measured 4.5-5.5  $\mu$  in diameter. Otherwise they could easily be placed under *L. Wrightii*. Whether they represent an ecological variation of this, or a new species, cannot be determined until further collections are made in that area.

#### 20. *L. cepæforme* Bull.

Basidiocarp globose or somewhat depressed, 8-20 mm. in diameter, plicate beneath with a cord-like root; outer peridium a thin, white, minutely furfuraceous coat, becoming rimulose and later breaking up into minute dehiscent scales, exposing the smooth, pale or light



brown surface of the inner peridium; subgleba nearly obsolete; gleba greenish-yellow, then brownish-olivaceous or brown (Verona brown or snuff brown); capillitium threads much branched, the main ones as thick as, or slightly thicker than the spores; spores globose, smooth, 3.5-4.5  $\mu$  in diameter, sometimes with a minute pedicel. (Plate II, fig. 21).

On ground in open woods. Dickinson County: West Okoboji, June. On sandy ground. Muscatine County: Bayfield, November. Reported from Ohio, Pennsylvania, Carolina, and Alabama.

Smaller forms of this species are liable to be referred to *L. pusillum*, but the outer peridium does not break up in such regular patches as the squamules of that species. Hollós lists this as a synonym for *L. furfuraceum* Schæff. and describes that form as "peridium furfuraceous with minute spines, becoming dark-brown or reddish-brown with age, as the gleba; the subgleba well developed." The material at hand is evidently not that. Saccardo regards *L. pusillum*, *L. cepaforme*, and several other forms as synonyms for *L. furfuraceum* Schæff., but considering the descriptions as given by these three men it seems best to follow Morgan who was guided by Masee and Quelet.

#### 21. *L. coloratum* Peck

Basidiocarp subglobose, 12-25 mm. in diameter and slightly less in height, plicate beneath, sometimes with a cylindrical, stem-like base, 2 mm. or less in length, with a fibrous mycelium; outer peridium a thin coat of minute persistent granules, discernible to the naked eye, whitish or yellowish at first, later light-brown (clay color to Sayal brown) or reddish-brown (dark Indian red), becoming dark-brown with age (Rood's brown); subgleba nearly obsolete; gleba at first yellowish, then brown-olivaceous (brownish olive); capillitium threads very much branched, the main ones thicker than the spores; spores globose, smooth, 3.5-4  $\mu$  in diameter, sometimes with a minute pedicel. (Plate II, fig. 22).

On ground in woods, somewhat caespitose. Iowa City, September. Reported from Wisconsin, Ohio, New York, and the New England states.

Hollós is uncertain as to the position of this form and only mentions it in connection with *L. furfuraceum* Schæff. Morgan records the diameter of the spores as 3.5-4.5  $\mu$ .

### PLATE I

All drawings were made with aid of camera lucida, oil immersion, at a magnification of 1450 diameters, and reduced one-third in reproduction. Figures one to twenty-two, inclusive, show spore and capillitium characters for species as listed below.

- |   |  |
|---|--|
| 1. <i>L. pulcherrimum</i>                           | 10. <i>L. pedicellatum</i> (basidiocarp lignatile) |
| 2. <i>L. rimulatum</i>                              | 11. <i>L. Curtisi</i>                              |
| 3. <i>L. hirtum</i>                                 | 12. <i>L. gemmatum</i> (spores minutely warted)    |
| 4. <i>L. asterospermum</i>                          | 13. <i>L. gemmatum</i> (spores smooth)             |
| 5. <i>L. atropurpureum</i>                          | 14. <i>L. pyriforme</i>                            |
| 6. <i>L. glabellum</i>                              | 15. <i>L. saccatum</i>                             |
| 7. <i>L. separans</i> (typical spore form)          | 16. <i>L. muscorum</i>                             |
| 8. <i>L. separans</i> (spores minutely warted)      | 17. <i>L. molle</i>                                |
| 9. <i>L. pedicellatum</i> (basidiocarp terrestrial) | 18. <i>L. oblongisporum</i>                        |

PLATE I

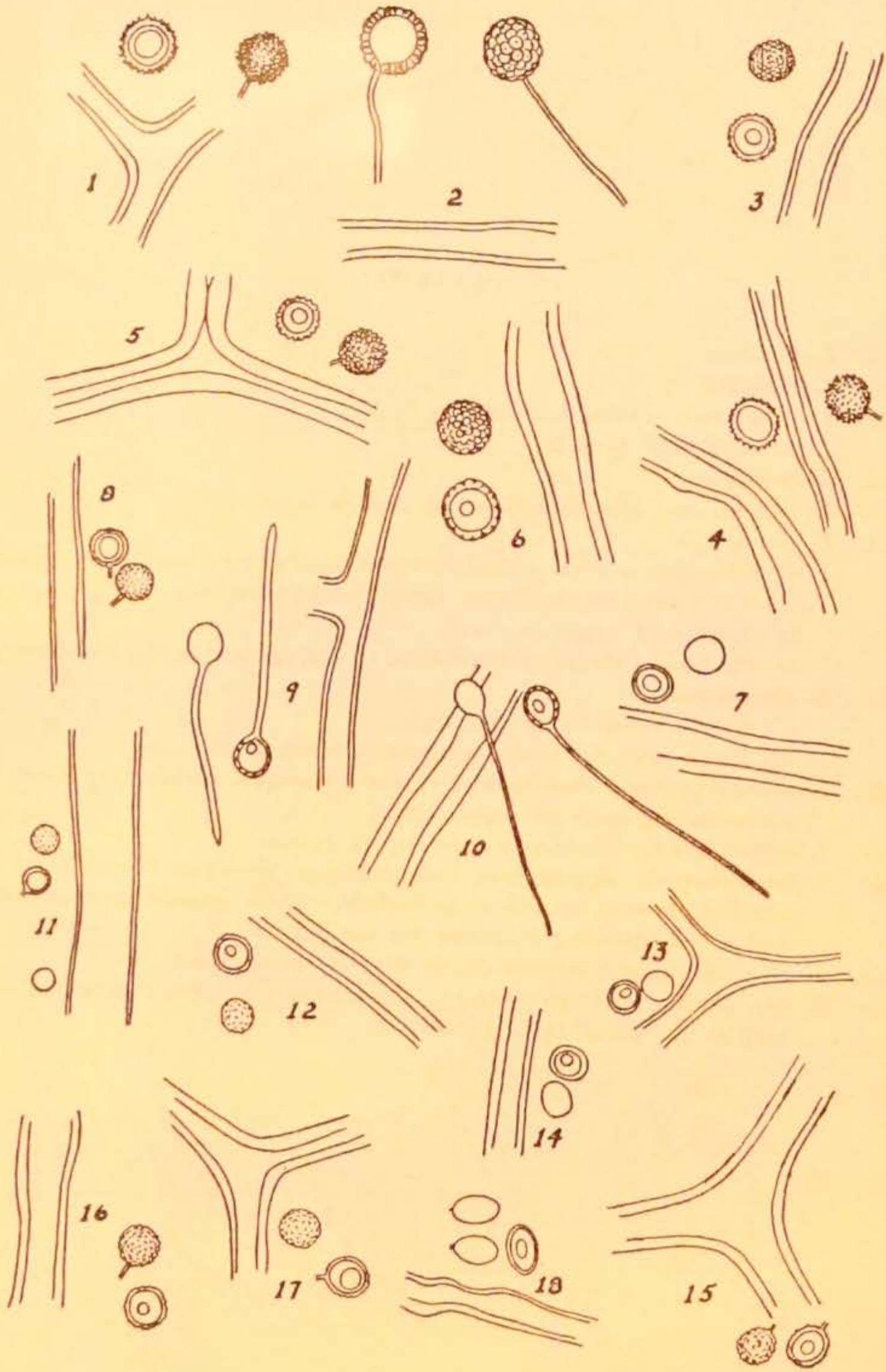
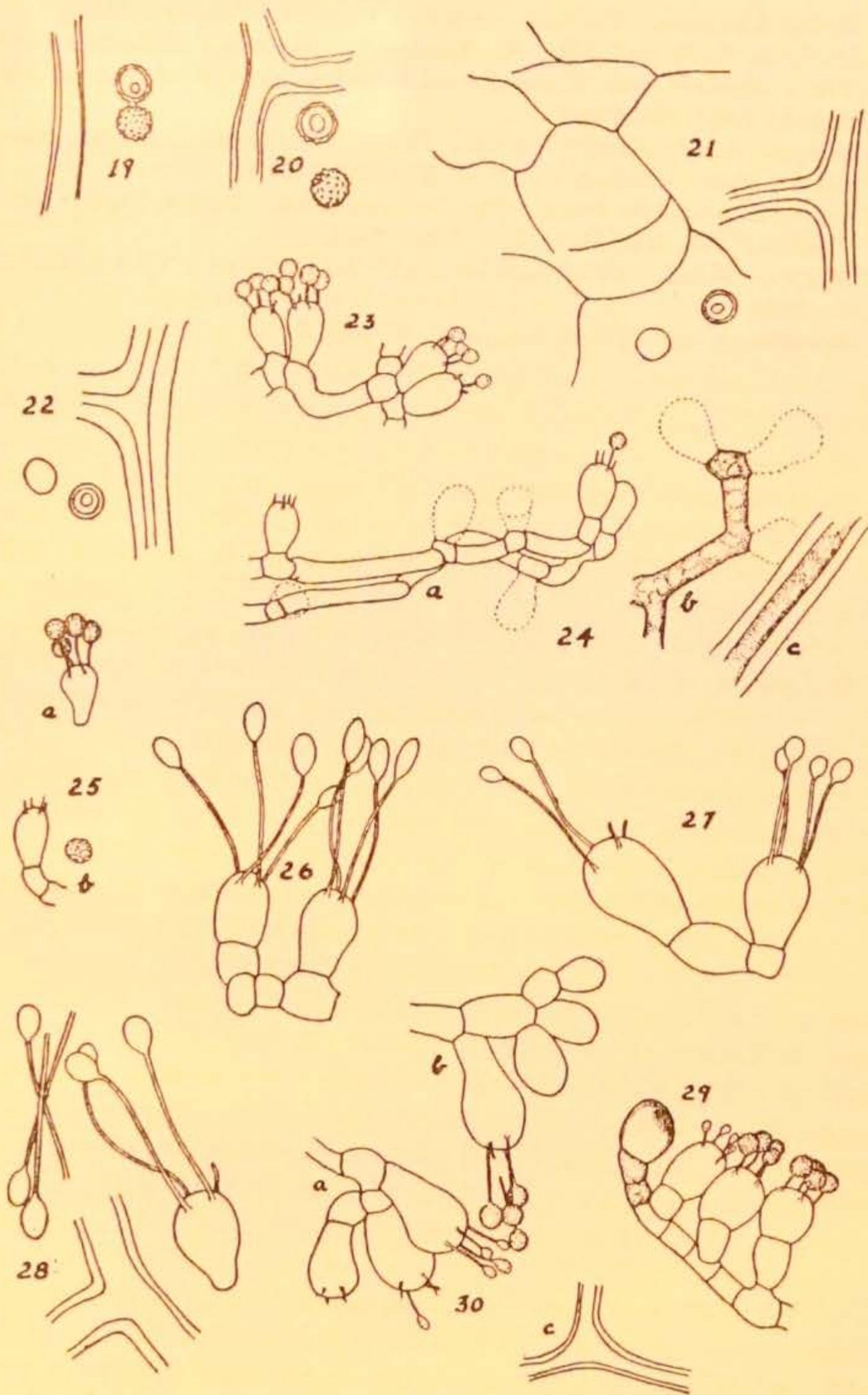


PLATE II

19. *L. pusillum*
20. *L. Frigida*
21. *L. repaferens* (note branching of capitulum threads)
22. *L. rotundum*
23. *L. granulatum*. Basidia and nearly mature spores.
24. *L. granulatum*:
  - a. Old basidia from a well matured basidiocarp; most of the gleba was a mass of capitulum threads and free spores.
  - b. Portion of hypha in detail.
  - c. Portion of thread of capitulum of average size in this basidiocarp.
25. *L. granulatum*:
  - a. Spores about to be discharged.
  - b. Free spores; old basidium about to disintegrate.
26. *L. rhizophorum*. Basidia and spores. Sterigma breaks very close to spore leaving spore short pedicellate.
27. *L. pedicellatum*. Basidia and developing spores.
28. *L. pedicellatum*. Spores free, and attached. Sterigma breaks close to basidium leaving spore long pedicellate. These pedicels are persistent and a distinguishing character for the species.
29. *L. sp.* Basidia and various stages of spore development.
30. *L. sp.* Basidia and spores (a,b); capitulum (c). From same basidiocarp as 29—probably *L. granulatum*.

PLATE II



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# THE GEASTERS OF IOWA

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The name *Geaster* was first applied to the fungi belonging to this group by Micheli (5) in 1729, but it was not commonly adopted until a century later, when Fries (3) revived it. In the interim the Geasters were included in the genus *Lycoperdon* by Gleditsch, Schæffer, Linnæus, Sowerby, Bolton and others. Persoon (1) modified the name to *Geastrum*, and was followed by Albertini and Schweinitz, C. G. Nees von Esenbeck and others. In accordance with the International Code, Persoon's name should be used, but it seems unwise to attempt to change a name so long established.

Micheli chose an unusually suitable name for the genus, basing his selection on the starlike appearance of the sporophore at maturity, at which time the outer peridium splits into from four to ten or more segments which become partially or wholly reflexed, thus giving the species their familiar stellate aspect.

Five species of *Geaster* were described by Micheli, though some critics of his work contend that only four are represented, due to duplication. One of these has since been placed in a separate genus, *Astræus*, concerning which more will be said later. Fries, in 1829, listed fourteen species, but he likewise included *Astræus*, as well as *G. coliformis*, which has been placed in a separate and generally accepted genus (*Myriostoma*) by Desvaux.

During the past century a large number of new species have been discovered by collectors all over the world, with the result that some seventy-five species are named in the list of illustrations in Saccardo's *Sylloge* in 1910, while Lloyd (4) states that one hundred and twenty-seven species of *Geaster* have been named. Lloyd estimates that only a fourth or perhaps a third of these are valid species. While his statement is probably extreme, certainly the list contains a large number of duplications.

Aside from desultory collecting there has been little work done on the Geasters in Iowa, and in view of this fact a taxonomic study of the genus was begun by the writer in the summer of 1926. The work has been carried on in the mycological laboratory of the University of Iowa under the direction of Prof. G. W. Martin.

## MATERIAL STUDIED

A considerable number of specimens of the genus are found in the herbarium of the University, including collections dating back to 1884. Many of them were collected by Prof. Bohumil Shimek and by Dr. T. H. Macbride, president emeritus of the University. Nine or ten species have been collected by persons connected with the mycological laboratory during the past three or four years. All told, some nineteen species are represented, of which all but four have been collected in Iowa.

In addition to the collections mentioned above, the extensive collection of Mr. A. P. Morgan is now the property of the University, and frequent reference to it has been made in classifying doubtful specimens. The Morgan collection contains many fine specimens from the more notable collectors of Europe and America, Lloyd, Ellis, Underwood, Macbride, Morgan, Hollós and Bresadola all being represented, as well as others less well known.

## OCCURRENCE

The Geasters belong to the Gasteromycetes, a subdivision of the Basidiomycetes, and are characterized by the peculiar sporophores, or fruiting bodies, born on their intricate webs of underground hyphæ. These bodies, which consist of two well defined parts, an outer tissue known as the exoperidium, and an inner spore sac called the endoperidium, usually grow almost to maturity just beneath the surface of the soil, although in some species they are formed partially or entirely above ground. Species of the former type are said to be hypogæal, and the mycelial outer layer completely covers the exoperidium. In the above-ground or epigæal species, however, a more or less cord-like group of mycelial fibers is attached at the base. Unexpanded fruiting bodies of different species vary in size from less than a centimeter to four and occasionally more centimeters in diameter.

The Geasters are saprophytic and are usually found in woods rich in humus. Ravines in which leaves have been allowed to accumulate and decay are particularly favorable places for them. Certain species grow about old stumps, while others are found directly on decaying logs. Moreover some species are found in the open prairie and others occur in sandy soils. Certain species are credited with the formation of mycorrhiza, although comparatively little is known of this subject.

Upon reaching maturity, which, in Iowa, is usually between



early August and the first week of November, the exoperidium splits into segments, the number varying somewhat in different species, and these open outwardly, giving to the sporophore the starlike appearance from which the name *Geaster* is derived. In doing this, the segments lift the sporophore out of the earth, and in certain species, elevate it somewhat above ground.

### STRUCTURE AND DEVELOPMENT OF THE SPOROPHORE

The exoperidium may be divided into three layers of tissue, an outer mycelial layer, a middle stratum known as the fibrillose layer, and an inner collenchymous one.

The mycelial layer, which is seen to best advantage in the unexpanded fruiting body, is composed of a more or less dense, fibrous mass of hyphæ, and is usually of a brownish color, and from less than one to about two millimeters in thickness. Outwardly strands run from this layer into the surrounding earth, and frequently sand, soil or humus particles are so closely woven into it that they cannot be separated without the destruction of the tissue. Inwardly the hyphæ of the mycelial layer run gradually into the fibrillose stratum. In some species this layer persists after maturity as a part of the sporophore, e.g. in *G. velutinus*; in others it splits away at the middle, but remains attached at the tips of the lobes of the exoperidium, e.g. in *G. limbatus*; and sometimes the inner layers form a relatively high arch over the mycelial layer, which remains as a cup-shaped body in the soil, e.g. in *G. coronatus*. In the latter case the specimen is said to be fornicate. In still other species the mycelial layer falls away at maturity, e.g., in *G. mammosus*.

The fibrillose layer is made up of closely woven hyphæ, and is continuous with the columella at the base of the endoperidium. DeBary (1) divides this into two layers which he calls a "thick stout membrane" and the "white layer", but he mentions their combination into one layer. Apparently no useful purpose is served by this subdivision.

The collenchymous or fleshy layer is composed of closely connected hyphæ in the more hygroscopic species, the thick cell walls of which have great capacity for absorbing water, which causes them to swell and produces the opening which occurs whenever sufficient moisture is present after maturity. Upon drying, these cells contract and the segments again close over the endoperidium. In the species which are only slightly hygroscopic, or not at all so, the hyphæ are rather loosely connected. In freshly expanded plants

this layer is usually flesh-colored and is soft and often quite thick. Upon drying, it shrinks considerably, and frequently changes color, a dull brown shade being quite common for dried specimens.

Cunningham (2) in his study of the development of *G. velutinus* has some excellent photographs at low magnifications, showing the layers just described in immature and nearly ripe specimens.

The following account of the development of the endoperidium is based largely on DeBary and Cunningham, as a lack of fresh immature specimens has prevented a study of this phase of the Geasters by the writer.

While the sporophore is still quite young, and just after the differentiation of the fleshy layer begins, a space filled with chambers or lacunæ appears in the endoperidium between the fleshy layer and the columella. These chambers, which are narrow, irregularly curved and branched, and too small, or barely large enough, to be discerned with the naked eye, are formed by the tearing apart of the glebal tissue, and are separated from one another by thin curved plates of branching hyphæ, which make up the trama. They occur in countless numbers and presently become lined with hymenial tissue, consisting of large irregular cells known as primary basidia. These basidia soon bear four spores on short sterigmata, although many at first are monosporous.

A period of rapid formation of lacunæ and basidia follows, until the whole interior, except the columella, is made up of tramal and basidial tissue. Each basidium produces four to eight spores which become detached, whereupon the basidium collapses and is replaced by another. As production of basidia and spores goes on, the plates of the trama diminish in thickness and the basidia decrease in size. These later and smaller basidia are called secondary basidia, and are usually four-spored. No difference in size of the spores born on primary and secondary basidia has been noticed.

DeBary states that two kinds of hyphæ are formed in the young trama, the first slender, delicate and segmented hyphæ, rich in protoplasm, which make up the chief mass; and the second, stouter tubes which are usually non-septate. Upon the ripening of the spores the smaller and more delicate hyphæ become dissolved and disappear, while the larger ones increase in size and in number and form the capillitium. With the development of the capillitium the columella becomes smaller and frequently only a rudiment remains in the mature specimen. The capillitium becomes a woolly mass of

loose texture, whose interspaces are filled with the ripe spores in the form of a dry powder, the whole being of a dark brown color.

At this time the outer peridium dehisces as described above, and spore dissemination is ready to begin, the formation of the mouth of the endoperidium having taken place as the spores developed.

Spore dissemination may be comparatively short in duration, or it may be a matter of several months. Specimens have frequently been found in the spring, which had presumably opened during the preceding autumn, whose endoperidia contained a considerable proportion of the original spore content.

#### CONCERNING THE VALIDITY OF THE GENUS *ASTRÆUS*

Morgan (6) in 1889 placed the species which had previously been called *G. hygrometricus* and which is worldwide in its distribution, in a separate and monotypic genus, to which he gave the name *Astræus*. Since that time there has been a considerable amount of discussion as to whether or not the genus should be allowed to stand.

Morgan based his action upon five characters of internal structure which he stated to be essentially different from all known Geasters. These characters are: "First, the hymenial tissue fills or stuffs the cells of the gleba, as in *Scleroderma*; second, the threads of the capillitium are long, much branched and interwoven, as in *Tulostoma*; third, the elemental hyphæ of the peridium are scarcely different from the threads of the capillitium and are continuous with them, in this respect agreeing again with *Tulostoma*; fourth, there is an entire absence of any columella, in fact it is precluded by the nature of the capillitium; fifth, both threads and spores differ greatly in size from those of Geasters.'

In addition to the structural differences mentioned it seems to the writer that Morgan might well have added the following external characters to his list; 1) The mouth of the endoperidium is merely a torn aperture, a respect in which it differs from all known Geasters; 2) the surface of the endoperidium is quite rough, and on well-preserved specimens it may be clearly seen to be reticulated; 3) the exoperidium is much more hygroscopic than that of the true Geasters.

Morgan's new genus was not generally accepted at first. Thus, Macbride in 1898 said: "It seems to us that the genus *Geaster* is so naturally and easily limited by the peculiar dehiscence of its peridia, that our convenience is more conserved by maintaining the

old genus with the limits set by all mycologists from Micheli to Winter." Similarly Lloyd in 1902 failed to recognize the new genus. Fischer, however, writing in Engler & Prantl's work in 1900, not only accepted the new genus, but recognizing the structural characteristics which Morgan had pointed out, took it entirely out of the Lycoperdineæ, and placed it in the family Calostomataceæ of the order Pleetobasidiineæ (Sclerodermineæ of other writers). Here it occupies a place between the families Sclerodermataceæ and Tulostomataceæ, of which *Scleroderma* and *Tulostoma* are typical genera. It will be remembered that Morgan had pointed out the similarity of *Astræus* to these genera. Other students of the group, including Hollós, Coker and Gäumann have recognized the genus.

It does not seem surprising that early mycologists were led by the similarity of dehiscence between *Astræus* and *Geaster* to place them in the same genus, but the essential differences of structure which have since been discovered furnish us with abundant reason for following Morgan in placing them in separate genera, and for accepting Engler & Prantl's classification of *Astræus* in a different but related order.

There exists an unfortunate tendency on the part of certain European mycologists to write the name of this plant as *Astræus stellatus* (Scop.) Fischer. Fischer, who is, of course, responsible for this form, traced it from Scopoli's description of the plant as *Lycoperdon stellatum*. While strict priority would seem to give this name preference over Morgan's form, *Astræus hygrometricus* (Persoon), yet the latter is correct according to the International Code, and it also has the sanction of much wider use. Believers in strict priority will be interested in the description of this species found in Micheli's work, which antedates that of Scopoli by more than thirty years.

#### HYGROSCOPICITY AND GERMINATION

The ability of the old sporophores of *Astræus* to respond to every change in moisture conditions surrounding them, opening whenever sufficient moisture is available to expand their collenchymous cells, and closing when this moisture is lost, has long been a subject of comment.

The writer has performed a number of experiments on hygroscopticity with dried herbarium specimens of *Astræus*, and has compared them with species of true Geasters.

When placed in a watchglass containing a few cubic centimeters

of water a specimen of *Astræus hygrometricus* requires from five to about twenty-five minutes to open completely, that is, for the segments to become parallel with the substratum. The segments usually turn back enough to expose the endoperidium to plain view in a third or a half of the time mentioned.

A slight amount of expansion may frequently be noticed within two or three minutes, and from that time on a person watching closely can see the slow movement of the segments. Specimens thirty years old seem to expand as readily as do those recently gathered.

*G. mammosus*, which exhibits more hygrosopicity than any other of the true Geasters observed, seldom expands completely in less than twenty minutes, and usually takes from thirty minutes to an hour or longer. No other of the species studied expands as rapidly, and some showed no observable effect from the water.

Numerous attempts to germinate the spores of various species have proved fruitless. We note that others have had the same experience. Thus, Cunningham says: "This peculiarity of non-germination under all laboratory conditions is apparently common in all the Lycoperdaceæ, for the writer has failed in all attempts to germinate spores of *Bovista*, *Bovistella*, *Calvatia*, *Disciseda*, *Geaster* and *Lycoperdon*."

#### EXPLANATION OF THE KEY

In describing and making a key to the species of *Geaster* a number of difficulties present themselves. Characters which have for years been regarded as constant by students of these forms have occasionally proved unreliable or impracticable, and have necessarily been abandoned. The lack of knowledge concerning variation within the species due to environment has been a handicap, and has in all probability been the cause of the large number of new species of *Geaster* which have been described in recent years. Nearly every paper on the subject which has been published includes a cancellation of some other mycologists new species, and the announcement of one or more of the author's own. It has therefore been my purpose in preparing the accompanying key and descriptions to avoid insignificant variations and to classify the species at hand so far as possible in accordance with the descriptions furnished by the older mycologists, including Schæffer, Persoon, Fries, Berkeley, Morgan, and others.

The form of the mouth is usually a good character, except in old and ill-preserved specimens, and a wider use than has been custom-

ary will be made of it. The figures in Plate I show the five different kinds of mouths which are characteristic of the different species of *Geaster*. They are as follows: 1) sulcate; 2) definite and grooved; 3) pseudo-sulcate; 4) indefinite; 5) definite, not grooved.

By a sulcate mouth is meant one which is folded or ridged in a fanlike manner. In true sulcate mouths it is easily possible to count the ridges, and the number will be found usually to vary between ten and twenty. A hand lens may be necessary for this. While the number of ridges is of little or no importance, yet the fact that they can be counted may be of aid in distinguishing between true sulcate mouths and others with which they might be confused.

A definite and grooved mouth is always outlined by a distinct narrow groove. Sometimes this may appear like a seam with the smooth side out, or it may be more prominent, but it is more than the edge of a depression in which the mouth is seated. Usually the color and texture of these mouths differ from those of the surrounding endoperidium.

The pseudo-sulcate mouth may at first glance be taken for a true sulcate one, but on closer examination the ridges will frequently be found to run only part way to the base, and to be somewhat twisted. In addition to these differences it is not usually possible to count them accurately as in a true sulcate mouth. This form of mouth is longer and more truly conical than the others described.

The indefinite mouth has no distinct boundary of any kind. Whatever differences of color and texture exist shade gradually into the surrounding endoperidium, rather than changing suddenly at a definite place. Such mouths are never seated in a circular depression.

The fifth type of mouth is that with a distinct boundary, but without a groove. This boundary may be the edge of a depression in which the mouth is situated, or it may be a change in color or of texture.

Another form which perhaps might be mentioned does not fall into our group of true *Geasters*, but has long been associated with them. This is *Astraus hygrometricus*. Instead of a mouth resembling any of those described above it has a simple torn aperture. Early botanists sometimes described this species as having a stellate mouth, as specimens were sometimes found with four or five short radial lacerations or tears centering in the aperture mentioned above. This seems to be an accidental feature, and is probably due

to repeated opening and closing of the segments of the outer peridium, which frequently tear the membrane of the endoperidium with their sharp points.

The presence or absence of a stalk or pedicel between the outer and inner peridia has long been considered a good character. Those with the stalk are said to be pedicellate, while those without it are sessile. Lloyd has shown that this may be misleading at times, and he states that *G. rufescens* may occur with or without it. He explains this by the shrinking of the unusually thick collenchymous layer of this species, which surrounds the pedicel of the fresh plants, but exposes it upon drying and shrinking. There seems to be no other record of both forms occurring within a species.

One of Morgan's key characters which has been abandoned is the shape of the unexpanded specimen, which may be either globose or acute. By applying the terms acute and acuminate to the tips of the segments of the expanded specimen he made the same distinction, an acuminate tip presumably indicating an acute unexpanded form. I have seen both globose and acute unexpanded specimens from a single collection of one species, and have, therefore, eliminated this character from my key.

One of the most difficult characters that has been retained is represented by the term "saccate." By this is meant that in the expanded form the central portion of the base forms a cup-shaped depression in which the sessile inner peridium is seated. This depression may be from one-fifth to one-half as deep as the inner peridium is high.

By fornicate, I have followed Lloyd in meaning "arched over the cup-shaped mycelial layer," rather than simply "arched," the more common meaning of the word.

In the matter of color, Ridgway (8) has been my criterion, although his exact terminology has usually been preceded by more general and common terms for the sake of speed and for the convenience of those to whom Ridgway's work is not available.

Some surprise may be expressed that the accompanying key does not contain Dr. Macbride's species, *G. juniperinus*. A careful examination of this species has convinced me that it may be correctly classified as *G. coronatus*. External characters coincide, except for the fact that there are more segments of the exoperidium than we usually find in this species, it being in this respect more like *G. minimus*. A comparison of the spores shows little observable dif-

4. *G. mammosus* Chev.

Exoperidium split halfway to the base into 7-10 parts; dark, sometimes almost black within; brownish to gray and smooth outside; diameter 3-5 cm. when open. Hygroscopic.

Endoperidium subglobose, sessile, brownish; 1-1.5 cm. in diameter. Mouth of different texture and color from surrounding endoperidium, but not grooved. Columella "short, globose, evident, though indistinct in mature plants."—Lloyd.

Capillitium subhyaline individually; dark brown (seal or clove brown, Ridgway) in mass; 3-4  $\mu$  in diameter. Spores globose, minutely warted; about 4  $\mu$  in diameter.

Distribution: Pennsylvania to California; Europe.

This is the most hygroscopic of our common Geasters. It has sometimes been confused with *G. saccatus* to which it bears a superficial resemblance, particularly in the unexpanded form. Its thicker and somewhat brittle exoperidium makes it easy to distinguish from *G. saccatus*.

5. *G. limbatus* Fr.

Exoperidium split about halfway to the base into about 7-8 lobes; the mycelial layer separating from the exoperidium in the middle and a little way out on the segments, but remaining attached at and near the tips. Not quite what we would call truly fornicate, but nearly so. Color light brown (clay to cinnamon buff, Ridgway) when fresh, becoming darker upon drying, also becoming cracked. Diameter 4-5 cm. Unexpanded specimens subglobose, sometimes with a slight papilla at the tip. Diameter unexpanded 2.3-3.5 cm. Root cordlike.

Endoperidium depressed globose; sessile when fresh, but becoming pedicellate upon drying; grayish brown (tulleul-buff, Ridgway); size 1.8-2.5 cm. Mouth different in texture and lighter in color than the endoperidium, but not grooved. Columella globose.

Capillitium brown (mummy brown, Ridgway); 4-6.5  $\mu$ . Spores globose, warted, 4-5  $\mu$ .

Distribution: New England and west to Kansas.

6. *G. triplex* Jungh.

Exoperidium split into 5-7 segments. Lower half of inner fleshy layer sometimes forming a cup about the endoperidium, whence the name *triplex*. The upper half usually remains adnate to the tips of the segments. Segments, when fresh, light brown (cinnamon buff,



Ridgway). Size when open 4-5.5 cm. Unexpanded specimens *globose or acute*. Size 1.5-3.5 cm.

Endoperidium depressed globose, sessile, light brown, (avellaneous, Ridgway); diameter 1.8-2.5 cm. Mouth different in texture from the surrounding endoperidium, but not grooved; sometimes seated in a slight depression. Columella clavate to obconic.

Capillitium dark brown to sooty black; varying from 2-7.5  $\mu$  in diameter, but averaging about 4  $\mu$ . Spores globose, warted, 4-6  $\mu$ .

Distribution: New England west to Iowa; Canada.

#### 7. *G. saccatus* Fr.

Exoperidium 6-9 times divided, the tips turning under when completely open. Base saccate; unexpanded specimens acute; diameter 2-5 cm. open.

Endoperidium subglobose, sessile; brownish with tinge of red sometimes (wood brown, Ridgway). Diameter 1.-1.5 cm. Mouth usually lighter colored than surrounding tissue and of different texture; somewhat conical. Columella slender and reaching the center of the spore sac; sometimes scarcely discernible.

Capillitium hyaline; brown (buffy brown to bister, Ridgway) in mass; about as thick as spores. Spores globose, minutely warted; about 4  $\mu$  in diameter.

Distribution: New England to Kansas.

This is one of the more common species, and can be found in rich woods from early in August to the middle of the autumn.

#### 8. *G. velutinus* Morg.

Exoperidium split into 6-8 segments; outer layer tending to separate from the inner ones; outer one a thin brittle membrane, appearing dull and rough. Saccate, and about 4 cm. in diameter.

Endoperidium sessile, subglobose; brownish (wood brown, Ridgway). Diameter 1-1.5 cm. Mouth usually lighter colored than surrounding tissue, and sometimes set in a slight depression. Columella scarcely discernible.

Capillitium dark brown (bone brown, Ridgway). Spores globose, minutely warted, about 3.5  $\mu$  in diameter.

Distribution: Florida, North Carolina, Ohio, Pennsylvania, Iowa, Canada, Samoa.

#### 9. *G. fimbriatus* Fr.

Exoperidium cut to 6-8 segments whose tips turn under when completely open, leaving the base shallowly saccate. Diameter 3-4.5

cm. open. Outer layer of exoperidium tending to split away from the others.

Endoperidium subglobose and sessile, light brown (wood brown, Ridgway) in color. 1.2-1.6 cm. in diameter. Mouth indefinite, slightly lighter in color but shading into the surrounding tissue.

Capillitium brown (avellaneous, Ridgway). Spores globose, minutely warted, 3.5-4  $\mu$ .

Distribution: New England, North Carolina, South Carolina, Iowa, Kansas, California, Europe.

This plant is very close to *G. saccatus*, with which it is frequently confused. A glance at the indefinite mouth should be sufficient to classify it properly and to distinguish it from closely related species.

#### 10. *G. rufescens* Pers.

Exoperidium 6-8 parted, split halfway to the base, the segments reflexed to form an arch. Fleshy layer drying thick and hard, and giving an appearance suggestive of rough leather. Diameter about 5 cm. open.

Endoperidium grayish to brown (pinkish-buff, Ridgway); globose; sometimes distinctly pedicellate, especially in dried specimens, but more often sessile. Mouth without a definite boundary; in old specimens sometimes appearing toothed. Columella globose.

Capillitium hyaline under magnification; light brown (warm buff, Ridgway) in mass; varying from narrower to somewhat thicker than spores. Spores globose, about 4  $\mu$ .

Distribution: New York to California; Canada; Europe.

According to Lloyd this species is the most abundant which we have in this country.

#### 11. *G. striatus* DC.

Exoperidium 7-9 parted, split halfway to the somewhat saccate base, or deeper; tips of the lobes acuminate, and the lobes recurved, but somewhat cupped about the endoperidium. Diameter when open about 4-5 cm.

Endoperidium with surface appearing velvety under hand lens; subglobose; sessile; light brown to brown (tilleul-buff, Ridgway); diameter about 2 cm. Mouth pseudo-sulcate, long, conical, and usually somewhat twisted; sometimes seated in a slight depression. Columella subglobose to subelavate.

Capillitium light to dark brown in mass (wood brown to buffy

brown, Ridgway); threads about twice as thick as spores. Spores globose, minutely warted, 3.5-4  $\mu$  in diameter.

Distribution: New York to California.

12. *Astræus hygrometricus* (Pers.) Morg.

Exoperidium cut into 7-20 segments which are acute at the apex. Segments thick and brittle, and strongly hygroscopic. Diameter when open 5-7.5 cm.

Endoperidium depressed globose; sessile; pitted or reticulated; whitish in color, becoming gray or brown. Mouth an irregular torn aperture. Columella none.

Capillitium much branched; hyaline individually but brownish in mass. Not so thick as the spores. Spores globose, warted, varying extremely in size, from 4-15  $\mu$ , but more commonly from 7-12  $\mu$  and averaging about 9  $\mu$ .

Distribution: Throughout the world in fields and woods and sandy soil.

The unusually large spores of this species are one of the outstanding characters. It is interesting to compare them with those of the true Geasters.

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PLATE I

- Fig. 1. *G. campestris*, showing sulcate mouth.  
Fig. 2. *G. coronatus*, showing mouth definite and grooved.  
Fig. 3. *G. striatus*, showing pseudo-sulcate mouth. (Note twisting of striæ.)  
Fig. 4. *G. fimbriatus*, showing indefinite mouth.  
Fig. 5. *G. triplex*, showing definite mouth without a groove.  
Fig. 6. *Astræus hygrometricus*, showing mouth a simple torn aperture.

All figures on this plate are two-thirds natural size.

PLATE I

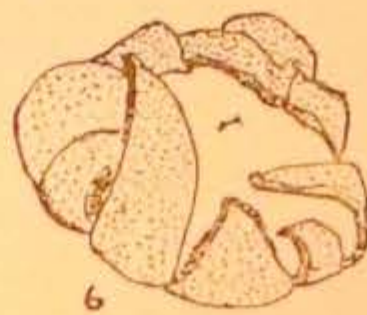
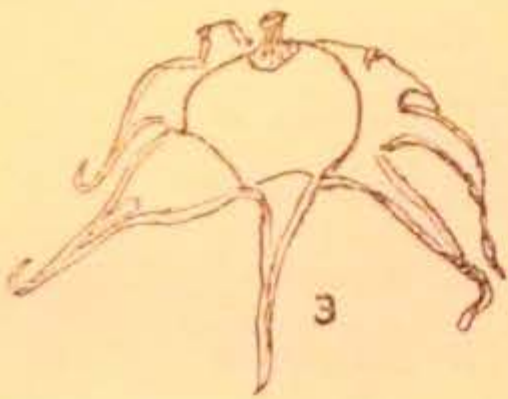


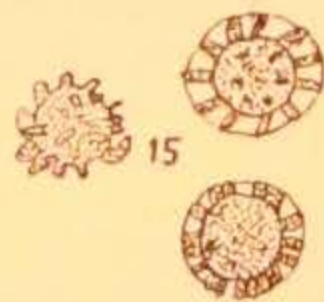
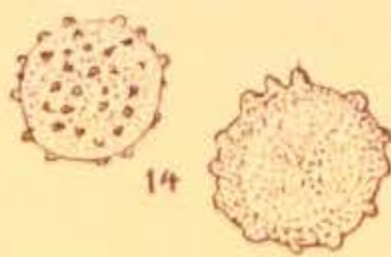
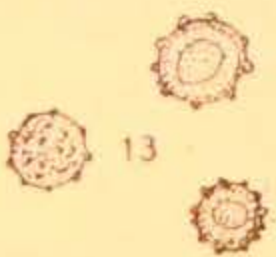
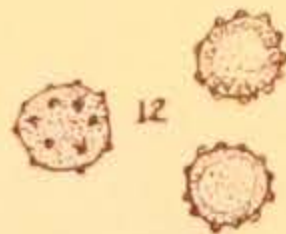
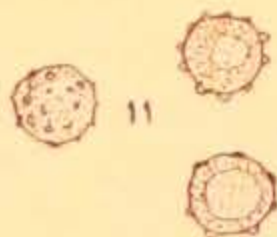
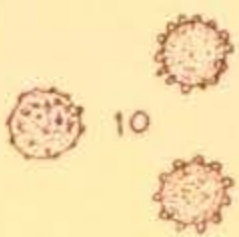
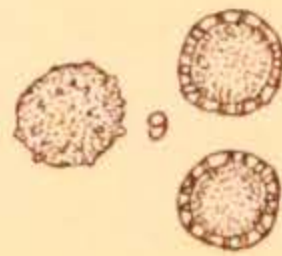
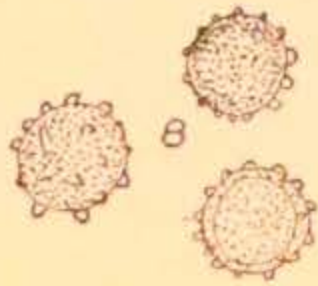
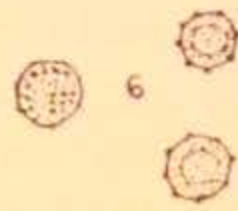
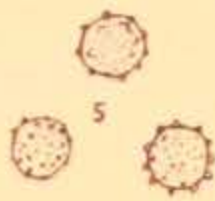
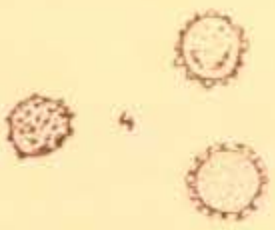
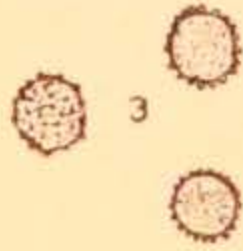
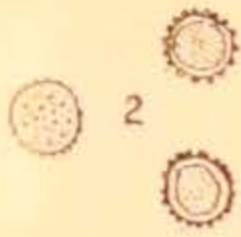
PLATE II

Spores of Geasters and Related Forms

- |   |                      |    |                               |
|---|----------------------|----|-------------------------------|
| 1 | <i>G. triplex</i>    | 8  | <i>G. Drummondii</i>          |
| 2 | <i>G. rufescens</i>  | 9  | <i>G. campestris</i>          |
| 3 | <i>G. limbatus</i>   | 10 | <i>G. mammosus</i>            |
| 4 | <i>G. striatus</i>   | 11 | <i>G. minimus</i>             |
| 5 | <i>G. fimbriatus</i> | 12 | <i>G. coronatus</i>           |
| 6 | <i>G. saccatus</i>   | 13 | <i>G. juniperinus</i>         |
| 7 | <i>G. velatus</i>    | 14 | <i>Astraeus hygrometricus</i> |
|   |                      | 15 | <i>Myriostoma coliformis</i>  |

The spores figured on this plate were drawn with the aid of a camera lucida at a magnification of 1730 diameters and reduced one-third in reproduction.

PLATE II



## THE THELEPHORACEAE OF IOWA

C. W. EMMONS

The fungi belonging to the family Thelephoraceae are characterized by the possession of simple basidia arranged, together with sterile organs, in a definite hymenium which is typically smooth.

The basidia usually bear four spores, but may bear only two, or rarely more than four, as in *Corticium vagum*. In any case the basidia are never septate or cruciate, but are similar to those found in the Agaricaceae. This character separates them from such tremellaceous fungi as bear a superficial resemblance to them. The hymenium, while typically smooth, may vary toward that of the Hydnaceae by bearing granular or tubercular roughenings; or toward that of certain of the Polyporaceae by exhibiting folds and thickenings. *Craterellus* suggests relationship with the Agaricaceae. It is usually possible to separate doubtful specimens upon the basis of other characters.

The fruiting structure varies from resupinate to stipitate and pileate. In the latter case the pileus may be lobed and divided into small fimbriate branches as in *Thelephora anthocephala*; it may be entire and central-stemmed as in some species of *Craterellus*; it may be the reflexed portion of a resupinate fructification as in many species of *Stereum* which may by becoming umbonate-sessile, approach the lateral-stemmed condition; or it may be slightly lobed and caespitously imbricated as in *Stereum rameale*.

Sections may reveal the presence of sterile structures of various types. These may consist of sterile paraphyses hardly distinguishable from immature basidia; of glæocystidia; of cystidia which may be incrusted or hair-like; of setae; or of otherwise differentiated hyphae. The spores may be even or rough-walled or echinulate; they may be hyaline or colored; they may be globose, cylindrical, or elongated. These characters and others constitute generic and specific differences which will be taken up in their respective relationships.

In the determinations of genera and of species the presence or absence of cystidia, glæocystidia, and setae often becomes of primary importance. Since there will be, in a few cases, difficulty in deciding to which of these categories a given organ belongs, a few words



regarding them may be worth while. A typical cystidium is tapering or conical, thick-walled, incrusted with granules or unincrusted, and without conspicuous cell contents. From this type of structure it may vary widely. It may be cylindric and septate; it may be thin-walled, hyaline, and emerging from the surface of the hymenium; or it may take the form of a somewhat irregular-shaped body heavily incrusted with obscuring crystals.

A glæocystidium is usually thin-walled, flexuous, hyaline, and with conspicuous cell contents. However, some glæocystidia are thick-walled and slightly colored. In some *Peniophoras* the distinction between cystidia and glæocystidia is made with difficulty. Glæocystidia take stain more deeply than cystidia.

Setæ are found only in *Hymenochæte*. They are rigid, even-walled, usually tapering and pointed organs and are always associated with tissue which darkens in 7% KOH solution. For this reason sections of species of *Hymenochæte* must be cleared and swelled with lactic acid.

The Thelephoraceæ are of common occurrence. The family contains both cosmopolitan species and species of local distribution. Their wide distribution and importance as wood-rotting fungi make the group worthy of study. Many species are important as causing dry rots of construction timber. Other species, by their frequent occurrence in our mesophytic woods, suggest their importance as humus formers. Probably they contribute to all stages of humus formation since they occur in habitats ranging from the bark of living trees to the under sides of very rotten logs. By reason of the hidden and protected location, the small size, and the restricted and resupinate habit of the fructifications, many species are often passed by and their importance in our fungal flora unsuspected.

The conception herein presented of the family and of its component genera is intended to be that held by Burt, and the nomenclature is that adopted by him. His excellent monograph, "Thelephoraceæ of North America," has been the basis for the determinations of the Iowa species studied. The existence of such an exhaustive and scholarly work simplifies very materially the study of a group, which from a taxonomic standpoint, is, at the best, difficult. Other treatments which have been of service in the preparation of this paper are: Coker, "Notes on the Thelephoraceæ of North Carolina"; Rea, "British Basidiomycetes"; Saccardo, "Sylloge Fungorum"; and others which will be cited elsewhere.

The method of study has been, in modified form, that outlined by Burt. A fragment of the specimen was moistened in water, using alcohol first when necessary. When thoroughly softened, excess water was removed and the piece sectioned in pith with a sharp razor. It is desirable to cut sections radially, i.e., parallel with the long hyphæ. The section was then examined and while under the microscope was cleared with 7% KOH; or, in the case of *Hymenochaete* with lactic acid. Spore-prints from fresh material were found very desirable. Colors named are those of Ridgway's "Color Standards and Nomenclature," 1912.

The diagnoses of genera and species are in general those of Burt, with such modifications as the study of our Iowa specimens suggests, or with such shortening of the descriptions as the fewer number of species permits. The arrangement of species corresponds to his.

In view of the existence of such an admirable taxonomic treatment of the group as is already contained in Burt's monograph, some justification may be necessary for the preparation of an additional treatment of the family. This is found in the services which local floras may render to the student of botany. Only the world-wide study of a family constitutes an adequate basis for determining the proper delimitations of a genus or of a species; but once such a study has been made, a local taxonomic study based upon conceptions so arrived at becomes an aid. Keys prepared for a restricted locality can be simplified and made more workable. Such a key to a group of relatively inconspicuous fungi may acquaint the botanist who does not profess to be a mycologist with a very interesting part of our flora. The keys here offered are admittedly imperfect but it is hoped that they may be found useful.

Most of the species described were represented in undetermined collections in the herbarium of the University of Iowa; and for the privilege of using this material, for suggesting the need for a local key, and for helpful suggestions and oversight during the study, the author gratefully acknowledges his indebtedness to Dr. G. W. Martin.

Besides unidentified collections, the herbarium contained several determined collections, and these were carefully checked over at the beginning of the study. Comparison with these and with specimens in published exsiccatae were of assistance in the determination of several species. In addition to the above, the writer made numerous collections during the first five months of 1927. It was somewhat

surprising to find fungi of this type in such excellent fruiting condition under the adverse conditions of an Iowa winter. *Aleurodiscus Oakesii* and some species of *Stereum* in particular were in excellent fruiting condition as early as January and must surely have been so during the earlier part of the winter. It was possible to get spore-prints from such material when it was brought into the laboratory, and the spores so obtained were viable. Spores of *Aleurodiscus Oakesii* were germinated on synthetic culture medium and then transferred to sterile wood of black oak. Upon this substratum the mycelium grew and reached the fruiting stage in the laboratory. Most of the collections were from the vicinity of Iowa City and from the Lake Okoboji region. Six species are here included which have been reported from the state but are not included among our collections. This report deals with 14 species of *Stereum*, 14 of *Peniophora*, 16 of *Corticium*, 5 of *Hymenochate*, 5 of *Thelephora*, 6 of *Hypochnus*, 3 of *Craterellus*, 3 of *Coniophora*, 2 of *Aleurodiscus*, 2 of *Solenia*, 1 of *Asterostroma*, and 1 of *Cyphella*. It is almost certain that a more extended survey of the state will yield many species not yet reported from Iowa.

#### KEY TO THE GENERA OF THELEPHORACEÆ

- |   |                         |
|---|-------------------------|
| 1. Spores colored .....   | 2                       |
| 1. Spores white in mass, hyaline under microscope, even.....  | 4                       |
| 2. Fruetification pileate.....  | 10 <i>Thelephora</i> .  |
| 2. Fruetification resupinate.....   | 3                       |
| 3. Spores rough-walled to echinulate.....   | 4 <i>Hypochnus</i> .    |
| 3. Spores even, ferruginous or fuscous.....   | 3 <i>Coniophora</i> .   |
| 4. Setæ (brown, cylindric, even-walled bodies) present in hymenium;<br>tissue darkens in KOH; fructification pileate to resupinate.....   | 11 <i>Hymenochate</i> . |
| 4. Setæ absent.....   | 5                       |
| 5. Fruetification cylindrical or cup-shaped and pendulous, 0.5-7 mm. high....   | 6                       |
| 5. Fruetification not as above.....   | 7                       |
| 6. Fruetifications cylindric or turbinate, gregarious, fasciculate, seated<br>on a superficial, floccose, hyphal subiculum.....   | 8 <i>Solenia</i> .      |
| 6. Fruetifications cup-shaped and pendulous, scattered or gregarious;<br>no subiculum present.....  | 7 <i>Cyphella</i> .     |
| 7. Fruetification resupinate or with free margin and drying cup-shaped;<br>spores large (16-23 x 11-14 $\mu$ ); paraphyses bushy-branched or of bottle-<br>brush form; often with much granular material in the fructification<br>..... | 6 <i>Aleurodiscus</i> . |
| 7. Not as above.....  | 8                       |
| 8. Fruetification infundibuliform or tubiform, subfleshy; hymenium<br>even or ribbed.....   | 9 <i>Craterellus</i> .  |

8. Not as above.....9
9. Fructification pileate to very narrowly reflexed, rarely resupinate (as in *S. umbrinum*).....12 *Stereum*.
9. Fructification always resupinate.....10
10. Brown, stellate organs present in the hymenium.....5 *Asterostroma*.
10. Such stellate bodies not present.....11
11. Cystidia present.....2 *Peniophora*.
11. Cystidia lacking.....1 *Corticium*.

### 1. CORTICIUM Persoon

Fructifications waxy, crustaceous or floccose, fleshy, cartilaginous, coriaceous, or membranaceous, always resupinate, effused; hymenium even or somewhat tubercular; basidia with 4 sterigmata usually (4-6 in *C. vagum*); basidiospores even, white (green in *C. atrovirens*).

*Corticium* contains species of widely varying structure and texture; but all have in common the resupinate habit, even, white spores (green in *C. atrovirens*) and all lack cystidia. The latter character distinguishes the genus from *Peniophora*. Glæocystidia may or may not be present.

### KEY TO SPECIES OF CORTICIUM

1. Fructification white to some shade of buff.....2
1. Fructification brown to vinaceous or blue.....13
2. Glæocystidia present.....3
2. Glæocystidia not present.....4
3. Fructification 150-200 $\mu$  thick; hyphæ loosely interwoven.....12 *C. septentrionale*.
3. Fructification 200-1000 $\mu$  thick; white to light buff; hyphæ agglutinate.....11 *C. lactescens*
4. Hyphæ densely and longitudinally arranged in a zone next the substratum, then more loosely ascending.....5
4. Hyphæ not so differentiated next substratum.....6
5. Hyphæ incrusted in subhymenium layer; spores globose, 5-6 $\mu$  in diameter.....6 *C. lacteum*.
5. Hyphæ not incrusted; spores 6-12 x 4.5-8 $\mu$ .....9 *C. roseum*
6. Hyphæ in subhymenium loosely interwoven.....7
6. Hyphæ in subhymenium densely interwoven.....9
7. Basidia not forming a compact hymenium.....14 *C. vagum*.
7. Basidia forming a compact hymenium.....8
8. Hyphæ usually 2-3 $\mu$  thick, but often with coarser hyphæ (up to 6 $\mu$ ) along substratum, not incrusted; 75-150 $\mu$  thick.....5 *C. centrifugum*.
8. Hyphæ 2.5-3.5 $\mu$  in diameter rarely incrusted in subhymenium; in section 100-300 $\mu$  thick.....3 *C. pelliculare*.
9. Fructification 40-250 $\mu$  thick; not at all separable; crystalline matter intermixed.....10

9.	Fructification 200-1000 $\mu$ thick.....	11
10.	Fructification 40-100 $\mu$ thick.....	2
10.	Fructification 100-250 $\mu$ thick.....	1
11.	Fructification not cracked; hyphæ suberect, hyaline, 1-2 $\mu$ in diameter, not incrustated, their curved ends forming the hymenial surface; spores 4-5.5 x 2-3 $\mu$ .....	4
11.	Fructification cracked; spores 5-12 x 3.5-8 $\mu$ .....	12
12.	Fructification cream-colored or pinkish-buff to wood-brown in herbarium; spores 8-12 x 5-8 $\mu$ .....	7
12.	Fructification whitish to cartridge-buff and light pinkish-cinnamon in herbarium; spores 5-9 x 3.5-6 $\mu$ .....	8
13.	Fructification deep bluish gray-green.....	16
13.	Fructification brown to vinaceous.....	14
14.	In section showing very numerous yellowish, stiff hyphæ with dichotomous and antler-shaped branching.....	13
14.	Not as above.....	15
15.	In section 75-100 $\mu$ thick; spores subglobose, 7-8 x 6-7 $\mu$ .....	15
15.	In section 120-500 $\mu$ thick; spores flattened on one side, 6-9 x 5-6 $\mu$ .....	10

### 1. *C. scutellare* Berk and Curtis

Fructification long and widely effused, thin, adnate, white, becoming cream-buff or warm buff in herbarium, waxy, often granular, cracked; in section 120-250  $\mu$  thick; hyphæ 2.5-3.5  $\mu$  in diameter, suberect, interwoven, incrustated in subhymenium; no glæocystidia or cystidia; spores 4-6 x 2-3  $\mu$ .

Fructifications 2-8 x 1-4 cm., on decaying wood of frondose species.

Our specimens lack the character of cracking and flaking away from the substratum, but the subhymenial zone of mineral matter together with the spore size and general characters serve for identification.

### 2. *C. crustaceum* (Karsten) v. Höhnel & Litschauer

Fructification effused, thin, crustaceous-adnate, white, somewhat granular, conforming to inequalities of the substratum, somewhat cracked; in section 40-100  $\mu$ ; hyphæ 2-4  $\mu$  in diameter, densely and longitudinally arranged along the substratum then more loosely ascending to the compact hymenium, crystalline matter intermixed; no glæocystidia; spores 5 x 3  $\mu$ .

Fructification 2-6 x 1-3 cm. long, on bark of frondose species.

### 3. *C. pelliculare* Karsten

Fructification broadly effused, thin, membranaceous, tender, small

pieces separable when moist, white to cream-buff, cracked and showing a cottony subiculum which extends as a white, fimbriate margin; in structure 100-300  $\mu$  thick; hyphæ loosely interwoven, with clamp-connections, sometimes incrustated; no glæocystidia; spores 4-6 x 2-3  $\mu$ .

Fructification 2-6 x 1-3 cm., on decaying wood. This species seems fairly common. Fresh specimens sometimes have folds in the hymenium such as to suggest a *Phlebia*, but become even on drying.

#### 4. *C. galactinum* (Fr.) Burt

Fructification long and broadly effused, becoming thick, coriaceous-soft, small pieces separable, white to cream-color, waxy, even, not cracked, margin indeterminate; in section 200-1000  $\mu$  thick; hyphæ 1-2  $\mu$  in diameter, suberect, densely interwoven, not incrustated; no glæocystidia; hymenial surface composed of the curved ends of hyphæ; spores 4-5 x 2-3  $\mu$ .

Fructifications 4-12 x 2-4 cm., collected at the roots of living *Ostrya*.

The thick hymenium (100-150  $\mu$ ) and the curved ends and branches of paraphyses forming its surface are important features. The subhymenium is somewhat loosely interwoven.

#### 5. *C. centrifugum* (Lev.) Bresadola

Fructification effused, very thin, arachnoid but forming a continuous pellicle, white to olive buff, margin byssoid; in section 75-150  $\mu$  thick; hyphæ loosely interwoven, 2-5  $\mu$  in diameter, but some next the substratum up to 6  $\mu$  in diameter; no glæocystidia; spores ellipsoidal, 4-8 x 2.5-4  $\mu$ .

Fructifications 2-6 x 1-3 cm., on decaying wood.

The elongated spores, very loose subhymenium with some large hyphæ next the substratum, and rarity of clamp-connections are good diagnostic characters.

#### 6. *C. lacteum* Fries

Fructification effused, thin, membranaceous, tender, small pieces separable, cream-colored to cinnamon-buff, cracked, margin whitish, fibrillose; in structure 150-300  $\mu$ ; hyphæ densely and longitudinally arranged next the substratum, then ascending to the hymenium, incrustated in subhymenium, no glæocystidia; spores subglobose, 5-7 x 5-6  $\mu$ .

Fructification 3-8 x 2-5 cm., on decaying wood and on the ground. Common.

Spores in our collection are slightly larger than Burt describes for the species, but are typical in shape. The dense longitudinal arrangement next the substratum is not always conspicuous, but in most specimens serves as a useful taxonomic character.

#### 7. *C. cremoricolor* Berk. & Curtis

Fructification broadly effused, rather thick, membranaceous, separable, cream-color to wood-brown, cracking, colliculose, margin narrow, fibrillose, sometimes radiate; in structure 200-800  $\mu$  thick; hyphæ longitudinally arranged, then ascending to a compact hymenium, not incrusted but mixed with granular material; no glæocystidia; spores flattened on one side, 8-12 x 5-8  $\mu$ .

Fructifications 2-10 x 1-3 cm. or widely confluent, on bark of decaying frondose species.

*C. cremoricolor* is similar in structure to *C. galactinum*, but is easily separated by its larger spores, tendency to crack, and by its paraphyses which do not form the hymenial surface.

#### 8. *C. confluens* Fries

"Fructifications effused, rather thick, waxy-membranaceous, small pieces separable when moistened, whitish to cartridge-buff and light pinkish-cinnamon in the herbarium, even, with few cracks, the margin indeterminate, thinning out; in section 200-500  $\mu$  thick, not colored, composed of ascending, densely interwoven and agglutinate, thin-walled hyphæ 2.5-3  $\mu$  in diameter, not incrusted, occasionally nodose-septate, no glæocystidia; spores hyaline, even, ovoid, 5-9 x 3.5-6  $\mu$ , copious.

Fructifications 2-8 cm. long, 1-3 cm. wide.

On bark of fallen, decaying limbs of *Betula*, *Alnus*, *Salix* and other frondose species." Burt.

I have not seen this species but it is reported from the state and Burt has examined Iowa collections.

#### 9. *C. roseum* Persoon

Fructification effused, rather thick, adnate, somewhat membranaceous, separable, pinkish-buff to buff-pink, pruinose, finally cracked, margin whitish, often byssoid; in section 200-280  $\mu$  thick, hyphæ sometimes slightly colored, densely and longitudinally arranged next substratum, then loosely interwoven or sometimes several hyphæ together forming loose strands, then erect and crowded again in the hymenium; no glæocystidia, spores 6-12 x 4.5-8  $\mu$ .

Fructifications 2-3 mm. in diameter or confluent over areas 1-10 x 1-3 cm., on bark and wood of frondose species.

*C. roseum* may become stratose. Since the immature basidia are exceeded by the paraphyses they are often hard to see.

10. *C. rubellum* Burt

Fructification broadly effused, thin, small pieces separable when moistened, vinaceous-fawn to wood-brown, even; in section 120-500  $\mu$ , becoming stratose with each stratum containing a zone of longitudinally woven hyphæ below the hymenium; no glæocystidia; spores 6-9 x 5-6  $\mu$ .

Fructifications 5-10 x 1-5 cm., on decaying wood and bark of frondose species.

11. *C. lactescens* Berkeley

Fructification broadly effused, rather thick, waxy-fleshy, small pieces separable, whitish to flesh-color and buff-pink, becoming light buff to avellaneous in the herbarium, cracking; in section 200-1000  $\mu$ , old specimens stratose; hyphæ longitudinally arranged along substratum; glæocystidia 60-120 x 4-9  $\mu$ , very numerous; spores 4-8 x 3-6  $\mu$ .

Fructifications 4-10 x 1-4 cm., on decaying logs.

The thicker specimens crack. The strata are composed of agglutinated hyphæ which may be intermixed with mineral matter.

12. *C. septentrionale* Burt

Fructification broadly effused, small pieces separable, drying snow-white, waxy, pulverulent, cracking; in section 150-200  $\mu$  thick; hyphæ loosely arranged below, suberect, bushy-branched, with clamp-connections; glæocystidia in hymenial layer up to 45 x 6  $\mu$ , often with capitate or moniliform tips; spores cylindric, 6-8 x 2-3  $\mu$ .

Fructifications 4-6 x 2-3 cm., on decaying wood. Common.

*C. septentrionale* is our one glæocystidia-bearing *Corticium* which dries snow-white.

13. *C. investiens* (Schw.) Bresadola

Fructification broadly effused, thin, tough, dry, warm buff to light orange-yellow, not cracked; in section 150-600  $\mu$ ; hyphæ yellowish, with dichotomous and antler-shaped branches; no glæocystidia; spores slightly straw-colored in mass, 12 x 4  $\mu$ .

Fructifications 2-20 x 1-5 cm., on rotten logs. Common.



There is no danger of confusing *C. investiens*. The stiff yellowish, branching hyphæ are the most conspicuous components of the fructification. The basidia are hyaline. The fructification is of chamois-like texture.

#### 14. *C. vagum* Berk. & Curtis

Fructification thin, arachnoid, more or less separable, pale olive-buff to cream-color; in section 60-100  $\mu$  thick; hyphæ 7-9  $\mu$  in diameter, hyaline (or dark next the substratum), not incrusted, without clamp-connections, running over substratum and giving rise to short branches which bear the basidia; basidia with 4-6 sterigmata, not forming a compact hymenium; spores flattened on one side, 8-14 x 4-6  $\mu$ .

Fructifications 5-10 cm. in diameter, on logs, or sheathing living herbaceous stems.

*Corticium vagum* is known most commonly in its imperfect stage as *Rhizoctonia Solani*. The latter is parasitic, forming minute sclerotia on the underground parts of various plants. Study of a collection of the perfect stage was made possible through the kindness of Dr. J. C. Gilman who sent material collected on *Solanum tuberosum* in one of the experimental plots at the Iowa State College. The spores of this material seem somewhat thicker and the apiculi more obtuse than in the spores figured by Burt.

#### 15. *C. vinaceum* Burt

Fructification effused, very thin, drying light pinkish-cinnamon to vinaceous-buff, even, not cracked; in section 75-100  $\mu$ ; hyphæ next substratum colored and agglutinated; hymenium 25  $\mu$  thick, no glæocystidia; spores subglobose, 7-8 x 6-7  $\mu$ .

Fructifications 5-10 mm. in diameter or confluent up to 4 x 2 cm.

Our collection seems to belong here. It agrees in all characters except that it was collected on oak instead of on coniferous wood. The margin is often whitish and thinning out.

#### 16. *C. atrovirens* Fries

Fructification thin, arachnoid, deep bluish gray-green, not cracked; in section 150-250  $\mu$ ; hyphæ without clamp-connections, not incrusted; no glæocystidia; spores bluish-green, subglobose, 3-4 x 2.5-3.5  $\mu$ .

Fructifications 1-4 x 1-2 cm., on decaying wood.

The blue-green color of the fructification separates *C. atrovirens* from our other species.

## 2. PENIOPHORA Cooke

Fructification waxy, coriaceous, cartilaginous, membranaceous, submembranaceous, floccose, or filamentous, always resupinate, effused, even; basidia 2-4 spored; spores white, even; cystidia present, incrusted or not incrusted, often immersed.

*Peniophora* and *Corticium* are separated by the fact that *Peniophora* has cystidia. This distinction is good except in the case of a few species in which cystidia are of such infrequent occurrence as to be missed altogether in some of the sections. In many cases cystidia are numerous at certain points such as over a lenticel through which the hyphæ have grown, but are absent in other parts. One might try to place such a specimen in either genus, depending upon the place from which his section was taken. Nevertheless the two genera are convenient divisions in what would otherwise be an even more difficult group of fungi.

## KEY TO SPECIES OF PENIOPHORA

- |  |                         |
|--|-------------------------|
| 1. Fructification less than 100 $\mu$ thick.....   | 2                       |
| 1. Fructification 200 $\mu$ thick or more.....   | 11                      |
| 2. Fructification white or yellowish to pinkish-buff.....  | 3                       |
| 2. Fructification drab to brown.....   | 9                       |
| 3. Spores 4-5 $\mu$ long; hyphæ incrusted.....   | 4                       |
| 3. Spores 6-15 $\mu$ long; hyphæ not incrusted.....  | 5                       |
| 4. Fructification 40-150 $\mu$ thick.....  | 4 <i>P. Thujae.</i>     |
| 4. Fructification 200-500 $\mu$ thick.....   | 5 <i>P. sanguinea.</i>  |
| 5. Spores 7-10 x 4-5 $\mu$ .....   | 6                       |
| 5. Spores 6-15 x 2.5-4 $\mu$ .....   | 8                       |
| 6. Fructification 60-150 $\mu$ thick; cystidia and yellowish glæocystidia present.....                                   | 11 <i>P. pertenuis.</i> |
| 6. No glæocystidia present.....  | 7                       |
| 7. Fructification 25-50 $\mu$ thick; cystidia which merge toward glæocystidia present but without true glæocystidia..... | 2 <i>P. albugo.</i>     |
| 7. Fructification 70-200 $\mu$ thick; unincrusted, hairlike cystidia present.....  | 3 <i>P. albula.</i>     |
| 8. White; spores 6-15 x 2.5-3 $\mu$ ; cystidia non-septate, 50-70 x 4-5 $\mu$ .....                                      | 1 <i>P. longispora.</i> |
| 8. Pinkish-buff; spores 7-10 x 3-4 $\mu$ ; cystidia septate, 200 x 10-14 $\mu$ .....                                     | 7 <i>P. sp.</i>         |
| 9. Hyphæ next substratum densely and longitudinally woven but not colored.....   | 10 <i>P. incarnata.</i> |
| 9. Hyphæ next substratum densely and longitudinally woven and colored reddish-brown.....                                 | 10                      |
| 10. Fructification ochraceous flesh-color, drying avellaneous; cystidia 40-50 $\mu$ x 15-20 $\mu$ .....                  | 14 <i>P. carnea.</i>    |

10. Fructification ashy to cinnamon-drab, resembling paint spilled on branches; cystidia 25-40 x 4-9 $\mu$ .....13 *P. cinerea*.
11. Fructification white or cream-color to vinaceous-fawn; separable from substratum .....12
11. Fructification wood-brown to avellaneous, cracking.....12 *P. sp.*
12. Fructification white to pinkish-buff, cracking; cystidia and glæocystidia usually present.....13
12. Fructification vinaceous-buff to fawn; not cracking; no glæocystidia .....5 *P. velutina*.
13. All of the glæocystidia slender, elongated or else differentiated middle portions of hyphæ.....9 *P. Allescheri*.
13. Glæocystidia present as expanded pyriform tips or branches of hyphæ .....8 *P. mutata*.

### 1. *P. longispora* (Pat.) v. Höhnelt

Fructification very thin, hypochnoid, not separable, becoming smoke-gray in the herbarium; in structure 30-120  $\mu$  thick; hyphæ loosely arranged, with clamp-connections; no glæocystidia; cystidia acicular, rough-walled, 40-80 x 3-4  $\mu$ , protruding up to 60  $\mu$ ; spores 6-15 x 2.5-3  $\mu$ .

Fructifications 3-10 x 1-5 cm., on bark and decaying wood of frondose species.

The peculiar cystidia and the very long spores are good characters, and the species is unmistakable.

### 2. *P. albugo* Burt

Fructification whitish, pale smoke gray in the herbarium, adnate, even, the margin indeterminate, pruinose; in section 25-50  $\mu$ ; basidia and cystidia starting from the substratum or with very few intervening hyphæ; no glæocystidia; cystidia not incrusted, 40-50 x 4.5-6  $\mu$ , protruding up to 40  $\mu$ ; spores 5-8 x 3-4.5  $\mu$ .

Fructifications 5-8 x 1.5-3 cm., on the under side of decaying frondose wood.

Burt bases his conception of this species upon specimens collected in Louisiana. There seems little doubt, however, but that specimens collected here are properly referred to it. The fructification resembles that of a *Corticium*, but the even, hyaline cystidia make it a *Peniophora*. In the specimen studied the hyphæ and basidia started directly from the substratum, and were hyaline below but greenish above because gorged with food.

### 3. *P. albula* Atkinson & Burt

“Fructifications long-effused, adnate, thin, tender, small pieces separable, white or becoming light buff when old and in the herbar-

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6. *P. sanguinea* (Fr.) Bresadola

Fructification effused, membranaceous, tender, substance arachnoid, margin byssoid, and often connected with blood-red mycelial strands which stain the wood red; in section 200-500  $\mu$  thick; hyphæ loosely arranged, some granule-incrusted; cystidia hair-like, not usually incrusted, 4.5  $\mu$  in diameter, protruding 20-30  $\mu$ ; spores 4.5 x 2-2.5  $\mu$ .

Fructifications 2-10 x 1-4 cm., on wood and fallen branches.

Burt describes the color of fresh material as being dragon's-blood red. I have seen only herbarium material which is faded to pinkish-buff. Some of the wood however is stained. When a fragment was put in water preparatory to sectioning it was partially disorganized and produced a milky precipitate provided it had been first moistened with alcohol.

7. *P.* sp.

Fructification broadly effused, tender, not easily separable when moistened, pinkish-buff in herbarium; hymenium somewhat granular, not cracked, margin determinate; in section 200  $\mu$ , composed of erect hyphæ and cystidia; cystidia cylindric, thick-walled, septate, 150-200 x 10-14  $\mu$ , emerging up to 50  $\mu$  and the emergent portion incrusted. Spores 7-10 x 3-4  $\mu$ .

Fructifications 4-7 x 2-3 cm. on *Populus*.

This specimen cannot be referred to any species described by Burt but its affinities with the *P. glebulosa* group seem plain. The cylindric, septate cystidia differ from the usual type.

8. *P. mutata* (Peck) Bresadola

Fructification broadly effused, membranaceous, fleshy, thick, separable when moistened, drying white to pinkish-buff; hymenial surface with raduloid teeth, or with radial folds, cracking in drying, margin byssoid; in section 300-1000  $\mu$  thick; hyphæ loosely arranged and ascending; glæocystidia pyriform, 15 x 7  $\mu$ , or elongated and flexuous, 100 x 4-5  $\mu$ , occurring as hyphal ends or as branches in the subhymenium; cystidia incrusted or not incrusted, 50-100 x 6-15  $\mu$ , not at all numerous; basidia 4-spored with short, thick, knob-like sterigmata; spores 8-16 x 3-4  $\mu$ .

Fructifications 3-7 x 1-3 cm. long or larger by confluence; common on *Populus*, *Tilia*, *Quercus*, and *Acer*.

The species approaches *Radulum* in structure and in the possession

of raduloid teeth, and is therefore an intermediate form between this and one of the related families.

9. *P. Allescheri* Bresadola

The diagnosis is almost the same as for the preceding species. Both species seem to vary widely in different parts of the same fructification. A section in one place may show numerous cystidia, in another place almost none. The frequency of glæocystidia varies in like manner. Burt separates *P. Allescheri* from *P. mutata* by the fact that the former has glæocystidia of the slender elongated form only, and originating apparently from middle portions of hyphæ. The glæocystidia of *P. mutata*, on the other hand, are terminal portions or branches of hyphæ swollen to pyriform shape or giving evidence of such origin. The distinction seems slight as a basis for specific differentiation. Examination of our specimens would seem to support Burt's suggestion that this difference is only a growth phenomenon and that *P. Allescheri* may therefore be only a synonym of *P. mutata*.

10. *P. incarnata* (Pers.) Karsten

Fructification effused, not separable, drying pinkish-cinnamon to warm buff, cracking, margin often paler and thinning out; in section 100-250  $\mu$  thick, not colored; hyphæ hyaline, thin-walled, densely and longitudinally woven along substratum, then suberect; glæocystidia usually numerous, sometimes 30-45 x 10-15  $\mu$  but usually 30-60 x 6-10  $\mu$ ; cystidia becoming incrusted, 30-45 x 6-10  $\mu$ , rarely emerging; spores 6-10 x 3-4.5  $\mu$ .

Fructifications as small tubercular outgrowths 2-5 mm. in diameter on lenticels of small limbs of frondose species; sometimes confluent over areas 2-10 x 1-2 cm. Common.

*Peniophora incarnata* is conspicuous by its reddish color. In section the numerous glæocystidia constitute a good taxonomic character. They arise from pyriform bodies near the substratum and become elongated and flexuous. Some sections fail to show any cystidia and the student attempting to identify a specimen with such a section might try to place it in *Corticium*. Cystidia are numerous in some parts of the fructification and are often variable in shape, sometimes being branched under the incrustation.

11. *P. pertenuis* (Karsten) Burt

Fructification long effused, not separable when moist, thin, waxy,

sterigmata; spores giving their color to the hymenium, even, 10-14 x 6-7  $\mu$ .

Fructification usually about 4-6 cm. in diameter or elongated up to 15 cm. long, 5 cm. broad, sometimes larger, 1/3-1 mm. thick.

On logs and woods of both coniferous and frondose species but more common on coniferous kinds." Burt.

I have not seen this species but it is reported from the state.

## 2. *C. conspersa* Fries

Fructifications broadly effused, membranaceous, tender, small pieces separable, drying old gold with margin byssoid or arachnoid, extending in radiating mycelial strands; hymenium pulverulent, not cracked; in section 100-150  $\mu$  of very loosely woven hyphæ which form a denser or closely woven pellicle at the hymenial surface; cystidia conical, heavily incrusted, 40-70 x 6-15  $\mu$ , tapering; subglobose bodies in subhymenium 12-15 x 8-10  $\mu$  which are probably immature glæocystidia. Spores oval or pyriform, pale, concolorous, 12 x 7-9  $\mu$ .

Fructifications 10-15 x 4-6 cm. on rotten wood.

In so far as the description is there given, this corresponds to *C. conspersa* Fr. of Saccardo. The golden pellicle is conspicuous to the eye and in section.

## 3. *C. sp.*

Fructification effused, soft, subfleshy, separable, flesh-color; in section 500  $\mu$  thick, of upright hyphæ, in regular, palisade arrangement, containing much granular material, apparently small incrusted cystidia in a zone 100  $\mu$  thick and 50  $\mu$  from base; glæocystidia (cystidia?) unincrusted, flexuous, often with moniliform tips, occasionally protruding; imbedded spores about 6  $\mu$  in diameter abundant in upper two-thirds of fructification and so arranged as to give a zonate appearance; basidia 2-spored; basidiospores 6-7 v 4-5  $\mu$ , flattened on one side, ochraceous when fresh, but now almost colorless and quickly bleached in KOH.

Over a small area at the base of living *Chenopodium* stem.

## 4. HYPOCHNUS Fries

Fructification resupinate, effused, dry, coriaceous, felt-like or hypochnoid, the loosely interwoven hyphæ bearing basidia, sometimes in scattered clusters, but usually in a compact hymenium; hymenium even or papillose; basidia bear 2 or more spores which are

rough-walled to echinulate and colored (hyaline in one extra-limital species).

Spore characters are less useful in *Hypochnus* than in other genera. In the same species spores vary not only in size but in shape and in type of roughening.

### KEY TO SPECIES OF HYPOCHNUS

1. Fructification byssoid not forming a membrane.....4 *H. sparsus*.
1. Fructification thicker, sometimes becoming stratose.....2
  2. Fructification brown to fuscous.....3
  2. Fructification benzo-brown to dark.....4
3. A few dark-colored hyphæ running along the substratum or consolidated into strands up to 18 $\mu$  in diameter.....1 *H. subferrugineus*.
3. Hyphæ concolorous with fructification, branching at wide angles.....
  - .....3 *H. spongiosus*.
  4. Zonate in section, hyphæ narrow and often conglutinate, but up to 4.5 $\mu$  in diameter next substratum, spores 10-12 x 7-9 $\mu$ .....6 *H. sp.*
  4. Not zonate, spores 5-7 x 6-7 $\mu$ .....5
5. Hyphæ pale under microscope; spores 6-7 $\mu$  in diameter.....2 *H. fuscus*.
5. Hyphæ colored, darker next substratum; spores 5-6 x 4-5 $\mu$ .....
  - .....5 *H. botryoides*.

#### 1. *H. ferrugineus* Burt

Fructification effused, dry, membranaceous, separable, Sudan-brown, surface often granular; in section 300-400  $\mu$ ; hyphæ along substratum dark colored, with clamp-connections, 5-6  $\mu$  in diameter, often interwoven into rope-like strands up to 18  $\mu$  in diameter, and giving rise to suberect, bright-colored hyphæ which bear the basidia; basidia four-spored; spores brown, subglobose, echinulate, body 7-9 x 6-8  $\mu$ .

Fructification 2-5 x 2-3 cm., on under sides of decaying logs.

*Hypochnus subferrugineus* has an uneven hymenium because the basidia are borne in clumps. New fructifications may form over the old making a stratose structure.

#### 2. *H. fuscus* Pers. ex Fries

Fructification effused, membranaceous, separable, cinnamon-drab, darkening to benzo-brown and Natal brown; in section 200-300  $\mu$  thick; hyphæ running over substratum and giving rise to loosely interwoven, branching hyphæ, pale under microscope, with clamp-connections; spores darker than hyphæ, subglobose, echinulate or short-aculeate, 6-7  $\mu$  in diameter.

Fructifications 2-10 x 1-2 cm., on rotten wood.

The specimen examined is now benzo-brown to dusky-brown.



3. *H. spongiosus* (Schw.) Burt

Fructification effused, soft, felty-membranaceous, separable, Saccardo's umber to bister, or rarely fuscous; in structure 200-1200  $\mu$  thick; hyphæ concolorous with fructification, with clamp-connections, branching at wide angles; spores globose or subglobose, 6  $\mu$  in diameter or 7-9 x 6-7  $\mu$ .

Fructifications 4-10 x 2-5 cm., on rotten wood and bark, or on the ground.

The hyphæ are loosely arranged in the subhymenium, ascending to a more compact hymenium.

4. *H. sparsus* Burt

Fructification effused, very thin, byssoid, not forming a membrane, drab; margin concolorous, indeterminate; in structure 60-75  $\mu$  thick; hyphæ short-celled, irregular, with clamp-connections; spores 4 to a basidium, grayish-olive under microscope, echinulate, 6-7 x 6  $\mu$ . KOH produces no noteworthy color changes.

Fructifications 2-3 x 1-2 cm., on bark of fallen limbs.

Not all the hyphal cells are short and irregular. This may be a form intermediate between *H. sparsus* and *H. pannosus*.

5. *H. botryoides* (Schw.) Burt

Fructification effused, membranaceous, separable, drying chætura-drab to fuscous, margin paler, brownish and floccose; hymenium granular; in structure 300-400  $\mu$  thick; hyphæ 3-4  $\mu$  in diameter, slightly colored, some along the substratum consolidated into rope-like strands; KOH solution causes color change to blue-green; spores angular-subglobose, aculeate, the spore body 5-6 x 4-5  $\mu$ .

Fructifications 1-5 x 1-4 cm., on rotten wood.

6. *H. sp.*

Fructification effused, not separable, in small patches or becoming confluent up to 1 x 4 cm., light drab, surface slightly granular, the copious spores giving a slightly brownish color to the drab hymenium; in section 200-300  $\mu$ , somewhat zonate; coarse hyphæ 4.5  $\mu$  in diameter next substratum, hyphæ in other parts smaller and sometimes conglomerate; many narrow paraphyses extend above hymenial surface, some are branched; basidia 2-4 sterigmate; spores echinulate to tubercular-angular, 10-12 x 7-9  $\mu$ ; color changes to lily-green in KOH.

On under side of rotten log.

The spores of this species are very variable, being echinulate or angular.

#### 5. ASTEROSTROMA Masee

Fructification resupinate, effused, dry, composed of loosely interwoven hyphæ, some of which terminate in brown stellate organs composed of slender rays; spores hyaline.

The stellate organs are very conspicuous in sectional preparations and sharply distinguish this from any other genus of the family.

##### *A. cervicolor* (Berk. & Curtis) Masee

Fructification avellaneous to cinnamon-drab, the margin fibrillose-floccose, paler; hymenium pulverulent; in section 150-300  $\mu$ ; hyphæ loosely arranged; stellate organs colored, rigid, with 3-7 unbranched rays 15-70  $\mu$  long and 3-4  $\mu$  in diameter; cystidia (glæocystidia ?) fusoid, often sharp-pointed, not incrusted, 30-45 x 8-12  $\mu$ , protruding up to 25  $\mu$ ; spores white, spherical, becoming echinulate, 4-5  $\mu$  in diameter.

Collected from soil in the University of Iowa greenhouse.

#### 6. ALEURODISCUS Rabenhorst

Fructification resupinate, sometimes with margin free all around and somewhat saucer-shaped, rarely dimidate and attached by the base, drying coriaceous; hymenium pulverulent; paraphyses with moniliform tips or with racemose or short lateral branches; much granular matter in fructification; basidia simple, large, 4-spored; spores large, with colorless cell-wall.

The two species of *Aleurodiscus* here described are unlike in habit, yet have in common the rather arbitrary characters upon which the genus is based.

#### KEY TO SPECIES OF ALEURODISCUS

- |  |                      |
|--|----------------------|
| 1. With free margin; paraphyses of bottle-brush form.....1 | <i>A. Oakesii</i> .  |
| 1. Resupinate; paraphyses corymbosely branched.....2       | <i>A. candidus</i> . |

##### 1. *A. Oakesii* (Berk. & Curtis) Cooke

Fructification pezizæform or resupinate with free, elevated, incurved margin, scattered or confluent, somewhat fleshy, drying coriaceous, whitish and tomentose on under side; hymenium concave, pulverulent, drying avellaneous; in structure 500-700  $\mu$  thick; hyphæ hyaline, sometimes incrusted; paraphyses with tips of two kinds, most are racemose with 8-12 short lateral branches, a few

with moniliform tips; basidia 80-100 x 12  $\mu$ ; spores even, 18-23 x 12-13  $\mu$ .

On bark of *Ostrya virginiana*, *Quercus alba*, and *Q. macrocarpa*, forming fructifications 2-5 mm. in diameter or becoming confluent up to areas 3 x 1 cm. Very common.

Burt describes the species as growing on bark of dead trees of the species named; but numerous collections have been made in this region, and nearly all from the bark of living *Quercus alba* and *Ostrya virginiana*.

## 2. *A. candidus* (Schw.) Burt.

Fructifications scattered, resupinate, adnate, white, pruinose, margin entire, blackening underneath; in structure 800  $\mu$ , somewhat stratose; hyphæ suberect, densely interwoven, heavily incrustated with large granules which often adhere by a tip only; paraphyses eorymbosely branched with bushy tips; spores even, subglobose, 15-17 x 11-14  $\mu$ .

Fructifications 3-20 mm. in diameter, on bark of trunks of living oaks; or rarely, on maple or ash.

Granular incrustations, large spores, and noteworthy paraphyses serve as distinguishing microscopic characters. In external appearance it is chalk-white and resupinate with only a narrow margin reflexed.

## 7. CYPHELLA Fries

Fructification somewhat membranaceous, cup-shaped, sometimes extended in stem-like form, pendulous; hymenium concave, inferior, even or rugulose; basidia 4-spored; spores sub-ovate or globose, hyaline, or rarely colored.

One species is known from the state.

### *C. Tilia* Peck ex Cooke

Fructifications gregarious, rather fleshy, minute, sessile or nearly so but with firm base, white, globose, then expanded and concave, villose, white, drying cup-shaped; spores white, even, ovate, somewhat curved, 12-18 x 6-7  $\mu$ .

Fructifications 0.5-1 mm. high, 0.33-1 mm. broad; stem, when present, 0.25-0.5 mm.; on dead branches of *Tilia* and of *Ulmus*.

*Cyphella Tilia* is in little danger of being confused with *Solenia* because its fructifications are less cylindrical and are not seated on a subiculum; nor with *Aleurodiscus* because of the minute size of

the fructifications. Our one species does seem to approach *Aleurodiscus* in external appearance and in its large spores.

### 8. SOLENIA Persoon

Fructifications coriaceous or membranaceous, sessile or nearly so, cylindric or turbinate, gregarious, fasciculate, rarely solitary, but not joined together except by confluence, seated on a superficial mycelium; spores white or colored.

1. Fructifications white or cream-colored.....1 *S. fasciculata*.  
 1. Fructifications some shade of brown.....2 *S. anomala*.

#### 1. *S. fasciculata* Persoon

Fructifications gregarious and usually fasciculate, cylindric-clavate, 2-7 mm. high, white or slightly cream-colored, minutely silky, a white mycelium sometimes present; spores white 4-6 x 3-5  $\mu$ .

Collected on sodden hornbeam.

#### 2. *S. anomala* (Pers.) Fuckel

Fructifications drying Dresden brown, snuff-brown, or Rood's brown, turbinate or pyriform, crowded or scattered, hairy; hymenium paler; spores hyaline, even, cylindric curved, 8-11 x 1.5-4.5  $\mu$ . Dried fructifications 0.5-1 mm. high, 200-300  $\mu$  in diameter, where crowded 3-4 to 1 mm.

On dead wood.

### 9. CRATERELLUS Persoon

Fructification fleshy or membranaceous, our species tubiform or infundibuliform, hymenium waxy-membranous, distinct, continuous, adnate to the hymenophore, even or rugose, basidia simple, spores usually white.

We have three species of *Craterellus*, and of these, one does not agree with the description of any of Burt's species.

#### KEY TO SPECIES OF CRATERELLUS

1. Fructifications 4-8 cm. high; avellaneous to smoky-black; spores 12-16 x 6-10 $\mu$  .....2  
 1. Fructification 1.5-3 cm. high, flesh-color; spores 6-7 x 3 $\mu$ .....3 *C. sp.*  
     2. Hymenium cinereous-drab; stem blackish-brown..1 *C. cornucopioides*.  
     2. Hymenium and base of stem yellowish.....2 *C. ochrosporus*.

#### 1. *C. cornucopioides* L. ex Persoon

Fructifications gregarious or somewhat cæspitose, pileus thin with margin sometimes lobed and waved, tubiform, pervious, often

3. *T. regularis* Schweinitz

Pileus coriaceous, solitary, infundibuliform, or divided to the stem into triangular divisions, or flabelliform, fibrillose, drying tawny-olive, darker at the center or at bases of branches, margin lacerate; hymenium hair-brown or pallid; spores melleus to umbrinous under microscope, angular-tuberculate, 6-7 x 4.5-5  $\mu$ .

Fruetifications 6 mm.-2.5 cm. high; pileus 5 mm.-2.5 cm. broad; stem 3-15 mm. long, 1-1.5 mm. thick; on moss and humus in wet places.

4. *T. albido-brunnea* Schweinitz

Pileus sessile or very short-stemmed, effuso-reflexed or encircling small twigs and stems, coriaceous, spongy, cinnamon-buff or chestnut-brown, fibrous-tomentose, margin thick and entire; in section concolorous with pileus, spongy, up to 2 mm. thick; spores olive-buff under microscope, echinulate, 8-10 x 6-8  $\mu$ .

Pileus 2-4 cm. in diameter when encircling twigs, or 1-2.5 cm. long when reflexed.

*T. albido-brunnea* is distinct by its light color and spongy structure. It swells immediately in water and becomes soggy as though decayed.

5. *T. terrestris* Ehrh. ex Fries

Fruetification dark fuscous to fawn-color, coriaceous-soft, caespitose, obovate, with a short stem-like base, or dimidiate and sessile, or incrusting and effuso-reflexed; pilei may be imbricate or confluent, strigose or fibrous-squamulose; hymenium fuscous to fawn-color; spores pale fuscous, irregular, angular, sometimes slightly tuberculate, 6-9 x 6  $\mu$ .

On the ground.

In the case of our collections which are of the dimidiate, sessile type the pilei are 1.5-2 cm. long and about 1 mm. thick. The fructifications sometimes grow in larger caespitose clusters, 8 cm. in diameter, with pilei 3 cm. long.

6. *T. griseozonata* Cooke

Fruetification caespitose, coriaceous-soft, pileoli extended into a short sub-lateral stem, imbricate, applanate, silky-strigose, zonate with alternating Rood's brown and light-buff zones; hymenium Rood's brown, rugose, somewhat papillose; spores pale fuscous, angular, 6-9 x 6-7  $\mu$ . Single pilei 2-3 cm. in diameter.

This specimen seems certainly to be *T. griseozonata*; but the spores are distinctly echinulate. It is similar in structure to *T. albido-brunnea*. The pileus is silky-strigose and zonate. The paraphyses are sparingly branched and divided by septa into short cells.

### 11. HYMENOCHÆTE Lèveillé

Fructification coriaceous to hard, stipitate to resupinate, hymenium even or granular, containing setae, basidia simple, spores hyaline, even.

The genus is set off by the possession of setae which are conical, thick-walled, usually sharp pointed, colored organs, and by the fact that KOH darkens the hyphae. If one is in doubt as to whether structures under his microscope are setae or cystidia the test with KOH will solve the question. Lactic acid must be used for clearing. The degree of differentiation in sections and frequency and location of setae make it easy to determine the Iowa species of *Hymenochæte*.

#### KEY TO SPECIES OF HYMENOCHÆTE

1. Sections showing both a setigerous layer and a hyphal layer without setae .....2
1. Sections showing setae borne in all parts of the fructification.....4 *H. corticolor*.
2. Stratose, each of the two or more strata consisting of a setigerous layer and a hyphal layer.....3 *H. rubiginosa*.
2. Not stratose, i.e., consisting of but one setigerous layer and one hyphal layer .....3
3. Hyphal layer differentiated into an intermediate zone and a denser, darker bordering layer on the surface opposite the setigerous layer.....4
3. Hyphal layer homogeneous, not so differentiated.....5 *H. arida*.
4. Setigerous layer not over 50 $\mu$  thick.....1 *H. Curtisii*.
4. Setigerous layer more than 50 $\mu$  thick.....5
5. Setigerous layer 60-75 $\mu$  thick, setae fairly abundant, not at all crowded, all emerging .....2 *H. badio-ferruginea*.
5. Setigerous layer 100 $\mu$  thick; setae very numerous, in all parts of the hymenium and wholly immersed.....3 *H. rubiginosa*.

#### 1. *H. Curtisii* (Berk.) Morgan

Fructification effused, confluent, becoming reflexed, drying pliant, upper surface antique brown to hair brown, hymenium velvety, antique brown to chestnut; in section 140-240  $\mu$ , intermediate layer of longitudinally arranged or ascending hyphae, bordered by a denser zone, hymenium 25-30  $\mu$  exclusive of setae which are 60-80 x 6-8  $\mu$  and may emerge up to 65  $\mu$ ; setae few and far apart, tapering to a sharp point; spores allantoid, 6-7 x 1.5-2  $\mu$ .

Fruetifications confluent up to 30 cm., on the under side of limbs. Common.

The *Stereum*-like structure and scarcity of setæ in *H. Curtisii* are good diagnostic characters. The hymenium is cracked only rarely.

### 2. *H. badio-ferruginea* (Mont.) L veill 

Fruetification imbricated, conchiform, umbonate-sessile or reflexed, drying pliant, upper surface Sayal brown becoming zonate; hymenium snuff-brown, often minutely cracked; in structure 200-300  $\mu$  thick with an intermediate layer bordered by a dense zone on upper surface of pileus; set  acute, 50-75 x 8-16  $\mu$ , emerging up to 50  $\mu$ , abundant but not crowded; spores slightly curved, 4-6 x 1-2  $\mu$ .

Pilei 4-7 x 4-10 mm., often confluent, resupinate over areas 2-8 cm.; on erect, rotting stumps.

*Hymenochate badio-ferruginea* is similar to *H. Curtisii* in structure but has more numerous and tapering set .

### 3. *H. rubiginosa* Dickson ex L veill 

Fruetification coriaceous rigid, resupinate or reflexed, reflexed portion Brussels-brown to fuscous-black above, with ochraceous-tawny margin; hymenium setulose under lens, colliculose; in section 500-700  $\mu$  thick with intermediate layer of longitudinal wavy hyph  bordered by a dense, dark zone on upper surface of reflexed portion; set  very numerous, curved, acute, 50-60 x 5-6  $\mu$ , some emerging, starting from all parts of the setigerous layer; spores 4-6 x 2-3  $\mu$ .

Resupinate over areas 8 x 4 cm. and reflexed 1-2 cm.; on oak. Common.

The much thicker setigerous layer and more numerous set  make this distinct from other Iowa species. *H. rubiginosa* becomes stratosose. Burt does not note this, although two of the specimens cited by him in published Exsiccata  viz., Bartholemew, Fungi Col. 3133 and Ellis N. Am. Fungi 327, have two strata.

### 4. *H. corticolor* Berk. & Ravenel

Fruetification hard, woody, wholly resupinate and conforming to irregularities in substratum, or barely reflexed and black on upper side; hymenium drab to wood-brown; in structure 200-1000  $\mu$ , without intermediate layer; set  scattered throughout all of the section, crystalline matter intermixed, set  60-75 x 9  $\mu$ , emerging up to 45  $\mu$ ; spores 4.5 x 3.5  $\mu$ .

Resupinate over areas 1-3 x 1.5-5 cm.; in crevices in the bark of living trees.

None of the collections studied have contained fructifications so large as Burt describes. The usual size is 4-10 x 2-20 mm. Numerous collections have been made from crevices in the bark of living *Quercus macrocarpa*. The fructifications sometimes exhibit narrow inconspicuous whitish margins. The setæ are scattered throughout the section but are often more numerous in zones, thus giving a stratose appearance. This is undoubtedly a growth phenomenon to be explained by external conditions. Spores in spore-print 7-8 x 4-5  $\mu$  in our specimens.

#### 5. *H. arida* Karsten

Fructifications resupinate, confluent, thin, dry, adnate, not cracked, drying clay color to antique brown; in structure 100-140  $\mu$ , of closely interwoven suberect hyphæ without a bordering denser zone; setæ 30-75 x 6-8  $\mu$ , scattered through upper portion and emerging up to 35  $\mu$ , not numerous, tapering upward, spores 6-7 x 3-4  $\mu$ .

Fructifications becoming confluent over areas 9 x 2 cm., on bark of dead limbs of *Corylus*.

Our specimens seem to belong here but do not agree in all respects. Setæ are often brown below surface of hymenium and colorless above, basidia colorless. KOH intensifies color in the paraphyses and setæ. Lactic acid clears sections except in the hymenial region which becomes opaque and of a greenish-black color. Setæ are large, some being 95-120 x 6-8  $\mu$ .

#### 12. STEREUM Persoon

Fructification coriaceous to woody, our species dimidiate or effuso-reflexed or occasionally resupinate, sometimes almost lateral-stemmed by elongation of the umbo; hymenium inferior, without setæ; spores white, even in our species.

Among our Iowa Stereums several species such as *S. umbrinum*, *S. frustulosum*, *S. purpureum*, *S. Murrayi*, *S. hirsutum*, *S. cinerascens*, *S. roseo-carneum*, and *S. versiforme* sometimes assume a wholly resupinate habit or are only narrowly reflexed. In all measurements of thickness of the fructification the thickness of the tomentum is excluded.

#### KEY TO SPECIES OF STEREUM

1. Glæocystidia present; fructification coriaceous-fleshy, erumpent, peltate  
.....1 *S. rufum*.



- |   |                              |
|---|------------------------------|
| 1. Gloeocystidia absent.....  | 2                            |
| 2. Fruetification narrowly reflexed, almost resupinate.....   | 3                            |
| 2. Fruetification broadly reflexed, approaching lateral-stemmed condition ( <i>S. hirsutum</i> is sometimes only narrowly reflexed).....  | 9                            |
| 3. Pyriform, vesicular bodies present in hymenium or subhymenium.....   | 4                            |
| 3. Such vesicular bodies absent.....  | 5                            |
| 4. Coriaceous-soft, tomentose, hymenium not cracked.....  | 2 <i>S. purpureum.</i>       |
| 4. Corky, usually resupinate, sometimes reflexed and with the upper side a horny crust, vesicular bodies very numerous, hymenium cracking.....  | 3 <i>S. Murrayi.</i>         |
| 5. Paraphyses distinctive, i.e., branched or bottle-brush form, with or without cystidia.....   | 6                            |
| 5. Paraphyses not of distinctive form, incrusted cystidia present.....  | 8                            |
| 6. Cystidia present.....  | 12 <i>S. versiforme.</i>     |
| 6. Cystidia lacking.....  | 7                            |
| 7. Paraphyses with short lateral prongs, with prominent clamp-connections.....  | 14 <i>S. roseo-carneum.</i>  |
| 7. Paraphyses bottle-brush form, subhymenium zoned and containing much granular material, fructifications 3-5 mm. in diameter, woody.....   | 13 <i>S. frustulosum.</i>    |
| 8. Cystidia 100-200 x 6-10 $\mu$ , spores 6 x 3.5 $\mu$ .....   | 10 <i>S. umbrinum</i>        |
| 8. Cystidia 100-200 x 12-20 $\mu$ , spores 10-12 x 6 $\mu$ .....  | 11 <i>S. cinerascens.</i>    |
| 9. Fruetifications caespitose, radially plicate or crisped and folding together, colored conducting organs usually present (conducting organs usually present also in <i>S. hirsutum</i> but not numerous)..... | 10                           |
| 9. Fruetifications not caespitose but often laterally confluent, effuso-reflexed to wedge-shaped or umbonate-sessile; at first buff, becoming gray in age, sometimes zonate.....                                | 11                           |
| 10. Pilei 2-10 mm. long, crowded together and folded or crisped, strigose-hairy toward the base, marginal portion shining and zoned, 300-450 $\mu$ thick, a few colored conducting organs present.....          | 8 <i>S. rameale.</i>         |
| 10. Pilei caespitose-imbricated, villose to hirsute, tobacco-colored, 600-700 $\mu$ thick, colored conducting organs numerous.....  | 4 <i>S. gausapatum.</i>      |
| 11. Unincrusted cystidia present.....   | 9 <i>S. ochraceo-flavum.</i> |
| 11. Cystidia lacking.....   | 12                           |
| 12. Paraphyses bearing short prongs at the tip.....   | 13                           |
| 12. Paraphyses simple, pileus strigose-hairy on reflexed portion (sometimes effused with only a narrow margin reflexed), conducting organs which are slightly colored usually present.....                      | 5 <i>S. hirsutum.</i>        |
| 13. Pileus tomentose, 400-700 $\mu$ thick; spores 5.5-7.5 x 2.5-3 $\mu$ .....   | 6 <i>S. fasciatum.</i>       |
| 13. Pileus thin, 300 $\mu$ thick; spores 4-5 x 1.5-2 $\mu$ .....  | 7 <i>S. lobatum.</i>         |

### 1. *S. rufum* Fries

Fruetifications scattered or gregarious, coriaceous-fleshy, erumpent, with free margin; hymenium coarsely wrinkled, vinaceous-brown to oxblood-red when moist; in structure 600-2000  $\mu$  thick;

hyphæ incrusted, loosely ascending; gloecystidia 50-100 x 5-12  $\mu$  in hymenium, not emergent; spores white, even, curved, 6-8 x 1.5-2  $\mu$ .

Fructifications up to 1 cm. in diameter, on *Populus*.

This is our only species of *Stereum* which has gloecystidia. They are flexuous, densely filled with granular material, and seem quite distinct from the colored conducting organs found in several other species. The fructification suggests in appearance a tiny bright red *Auricularia*.

#### 2. *S. purpureum* Persoon

Fructification coriaceous-soft, resupinate or reflexed and imbricated with upper side villose-tomentose, light buff to cartridge-buff; hymenium light purple-drab to vinaceous-drab; in structure 500-800  $\mu$  thick; hyphæ rather loosely arranged in the subhymenium, pyriform, vesicular bodies, 15-30 x 12-25  $\mu$ , numerous; no cystidia; spores flattened on one side, 5-7 x 2.5-3  $\mu$ .

Resupinate portion 1-2 cm. in diameter, reflexed portion 5-20 cm. long; on frondose wood.

The pyriform or subglobose, vesicular organs are conspicuous. They are golden-yellow after treatment with KOH. The older ones are incrusted.

#### 3. *S. Murrayi* (Berk. & Curtis) Burt.

Fructification corky, adnate, resupinate or reflexed and with the upper surface a hard, horny crust; hymenium drying pale olive to avellaneous and cracking deeply; in structure 300  $\mu$  or stratose up to 2000  $\mu$ ; hyphæ 2.5-4  $\mu$  in diameter, suberect and densely interwoven; hyaline pyriform vesicular organs 15-20 x 12-15  $\mu$  in all parts of the fructification; no cystidia; spores flattened on one side, 4.5-5 x 2.5  $\mu$ .

Fructifications 1-10 cm. in diameter, reflexed 3-10 mm.; on rotten logs of frondose species.

The vesicular bodies are often so numerous as to give in clear sections the appearance of openings in a network.

#### 4. *S. gausapatum* Fries

Fructification coriaceous, effuso-reflexed, cæspitose-imbricated, laterally confluent, often radially plicate, villose to hirsute, buckthorn-brown; hymenium bleeding when fresh and drying discolored; in structure 600-700  $\mu$  thick, composed of densely arranged hyphæ

and numerous colored conducting organs, 75-120 x 5  $\mu$ ; no cystidia; spores 5-8 x 2.5-3.5  $\mu$ .

Pilei 1-2.5 cm. long or confluent over areas 10 cm. in diameter; on stumps of *Quercus*.

*Stereum gausapatum* is characterized by cæspitously imbricated, tobacco-colored fructifications; by the hymenium which bleeds when cut and is darkened in drying; and by presence in sectional preparations of flexuous, colored conducting organs. The more or less frequent presence of these organs together with some other common characters seems to indicate a very close relationship between *S. gausapatum*, *S. rameale*, and *S. hirsutum*. For other reasons *S. hirsutum*, *S. fasciatum* and *S. lobatum* are separated from each other only with difficulty. It is significant that conducting organs very similar to those found in *S. gausapatum* are usually present in *S. fasciatum* and *S. lobatum*, but are without color. The evidence from Iowa collections would seem to indicate that these five species are very closely related and have differentiated in different directions, but intermediate forms still persist. The only species with which *S. gausapatum* is in much danger of being confused is *S. hirsutum*; and from this it may usually be separated by the cæspitously imbricated pilei and more numerous colored conducting organs of the former.

#### 5. *S. hirsutum* Willdenow ex Fries

Fructification coriaceous, stiff, effuso-reflexed, rarely resupinate, strigose-hirsute, cream-buff, grayish when old; in section 350-700  $\mu$ ; hyphæ 3-4  $\mu$  in diameter, some thick-walled, 5-6  $\mu$  in diameter and containing golden-brown contents; spores 5-7.5 x 2-3  $\mu$ ; no cystidia. Reflexed up to 3 cm., on logs of frondose species. Common.

*Stereum hirsutum*, as in *S. rameale*, *S. fasciatum*, *S. lobatum*, and *S. gausapatum* has its intermediate layer bordered by a narrow, golden, denser zone forming a somewhat horny crust upon which the hairs are borne.

*Stereum hirsutum* sometimes becomes umbonate-sessile and then closely resembles superficially and microscopically *S. fasciatum*. It is here separated from the latter by the possession of colored conducting organs and the absence of paraphyses with short lateral prongs at the tips.

#### 6. *S. fasciatum* Schweinitz

Fructification coriaceous, rigid, broadly effuso-reflexed and soon

umbonate-sessile, pseudo-stipitate by elongation of the umbo; young specimens densely tomentose, drying warm buff, gray and often zonate when old and weathered; in structure 400-700  $\mu$ , no cystidia; spores 5.5-7.5 x 2.5-3  $\mu$ ; hyphæ spiny-tipped, i.e., with short prongs at the tips.

Fructifications 2-7 cm. in diameter becoming laterally confluent up to a foot in rare cases. Very common.

*Stereum fasciatum* is one of our most common species. It is separated from the preceding species by the possession of a few colored conducting organs and paraphyses with spiny branches at their tips. These seem to be constant characters and no more satisfactory criteria for distinguishing the two have been found. This species merges also with the next but is usually thicker and has a thicker tomentose covering.

#### 7. *S. lobatum* (Kunze) Fries

Fructifications coriaceous, rigid, thin, wedge-shaped, umbonate-sessile, at first tomentose, tawny-olive, becoming smoke-gray and zonate when loss of tomentum reveals chestnut colored bands, margin undulate and lobed; in structure 300  $\mu$ ; spores 4-5 x 1.5-2  $\mu$ , according to Burt. Pileus 3-7 cm. long, 2-6 cm. broad, laterally confluent.

The thin wedge-shaped pilei of *S. lobatum* together with the zonate appearance due to bands of tomentum alternating with bared chestnut-colored zones are taxonomic characters. Here, too, there are occasional hyphæ 5-6  $\mu$  in diameter with thickened walls. They do not have colored contents but are conspicuous in thin sections. By their position, their ascending direction, and general appearance, they suggest a conductive function.

#### 8. *S. rameale* Schweinitz

Fructification coriaceous, thin, rigid, effuso-reflexed, rarely resupinate, reflexed portion of small umbonate pilei, often lobed, the lobes drying folded together, fibrose-strigose, becoming glabrous on the marginal portion, cinnamon-buff to hazel, often zoned; in structure 300-450  $\mu$ ; hyaline hyphæ 3-3.5  $\mu$ ; colored conducting organs usually present; no cystidia; spores slightly curved, 6 x 2-2.5  $\mu$ .

On twigs and stumps of oak and other frondose species, covering areas 5-10 mm. in diameter or confluent up to areas 4 x 12 cm.; individual pilei 2-10 x 3-10 mm. Common.

*Stereum rameale* is constant in appearance, the pilei being smaller and less hirsute than those of *S. hirsutum* and with prominent chest-

nut zones. In section it shows a well developed intermediate layer, bordered by a narrow, golden zone as in forms previously described.

9. *S. ochraceo-flavum* Schweinitz

"Fructifications coriaceous, thin, small, effuso-reflexed, sometimes confluent along branches, often conical and attached by one side and the umbo and sometimes only by the umbo, the upper side villose-tomentose, somewhat furrowed, white, weathering gray; in structure 200-300  $\mu$  thick below the hairy covering, with intermediate layer becoming bordered on the upper side by a denser or colored zone when old and weathered, composed of densely and longitudinally arranged, hyaline hyphæ 3-4  $\mu$  in diameter; no colored conducting organs; hymenium even, yellow becoming cream-buff in the herbarium; cystidia not incrusted, obtuse, 20-25 x 4-6  $\mu$ , protruding up to 15  $\mu$ ; spores not found.

Reflexed portion 3-5 mm. broad, and about as long; scattered conical pilei 3-5 mm. in diameter.

On dead branches of frondose species." Burt.

This species has not been observed by me but is reported from the state.

10. *S. umbrinum* Berk. & Curtis

Fructifications coriaceous-spongy, resupinate, effused, often reflexed, light vinaceous-lilac to dark lavender but becoming snuff-brown in age; in structure 500-1000  $\mu$  thick composed of loosely interwoven, slightly brownish hyphæ, among which thick-walled, darker organs arise and curve upward, emerging as even rough-walled or incrusted cystidia, 100-200 x 6-12  $\mu$ , emerging up to 40  $\mu$ ; spores 6 x 3.5  $\mu$ .

On oak, hickory, and other frondose species forming resupinate fructifications which seem to begin as outgrowths at lenticels and become as much as 3 cm. in diameter or confluent up to areas 15 cm. in diameter.

Cystidia of *Stereum umbrinum* are suggestive of setæ of *Hymenochaete*, but are distinguished from the latter by failure to darken in KOH. This species does not have a differentiated intermediate layer and is so often resupinate that it may be taken for a *Peniophora*. Once known, its color, its loose structure, and its peculiar cystidia make it easily recognizable.

11. *S. cinerascens* (Schw.) Masee

Fructifications coriaceous, resupinate and effused; hymenium

minutely bristling with cystidia; in structure 400-600  $\mu$ ; cystidia incrustated, brownish at the base, conical, 100-150 x 12-20  $\mu$ , emerging 40-70  $\mu$ ; spores 10-12 x 6  $\mu$ , flattened on one side.

On logs of frondose species; resupinate 1-12 x 1-6 cm., reflexed margin 3-8 mm. broad.

The species is characterized by pinkish-buff hymenium, bristling with cystidia; and in section by the large cystidia, brownish at the base, and by the large spores.

#### 12. *S. versiforme* Berk. & Curtis

“Fructifications at first thin, effused, resupinate, adnate, orbicular, becoming confluent, finally thickening, cracking, and becoming narrowly reflexed and somewhat complicate and curling away from the substratum, the upper side uneven, plicate, somewhat fuscous or blackish; hymenium velvety, Prout's brown to bister, somewhat papillate; in structure 200-400  $\mu$  thick, composed of densely arranged, ascending and interwoven hyphæ, some of which are colored; hymenium usually simple but sometimes with one or two additional zones in some places, containing heavily incrustated, cylindrical cystidia 45-75 x 12-24  $\mu$  starting in various parts of the hymenium and subhymenium, wholly buried below the surface of the hymenium or emerging up to 15  $\mu$ ; hymenial surface velvety, with very numerous colored paraphyses with bushy-branched tips; spores hyaline, even, curved, 5-7 x 2-3  $\mu$ .

Fructifications 2-10 mm. in diameter, confluent over areas up to 7 x 2 cm.; margin reflexed about 1 mm. usually, rarely up to 2 mm.

On bark of dead limbs of oak, chestnut, birch, and other frondose species.” Burt.

This species is not in our collections but is reported from the state and Burt has examined Iowa collections.

#### 13. *S. frustulosum* (Pers.) Fries

Fructifications woody, resupinate, tuberculose, crowded as if confluent and then broken up into frustules; when reflexed the upper side black; in section 800  $\mu$  or more thick, many zoned, often with crystalline matter intermixed; hyphæ densely arranged, radiating from point of attachment, paraphyses of bottle-brush type.

Fructifications 2-4 mm. in diameter, on oak logs and stumps.

*Stereum frustulosum* with its pinkish-buff to white hymenium in woody little frustules on oak is unmistakable. The beginner must

not mistake the often abundant crystalline matter for vesicular structure.

14. *S. roseo-carneum* (Schw.) Fries

Fructification coriaceous-soft, thin, usually resupinate; hymenium cracking; light vinaceous-purple, changing to avellaneous when mature; in structure 250-300  $\mu$ ; paraphyses filiform, colored above and with short branched tips, less conspicuous after basidia appear; spores 6-9 x 4-5  $\mu$ , flattened on one side.

Fructifications 3-5 x 2 mm., becoming confluent over areas 7 x 2 cm.; on fallen limbs of frondose species.

*Stereum roseo-carneum*, by its resupinate habit and lack of a differentiated intermediate layer is troublesome. The branched paraphyses are distinctive.

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PLATES



PLATE I

- Fig. 1. *Corticium septentrionale*; a. basidium and spores; b. glæocystidium (x 700).
- Fig. 2. *C. lacteum*; a. section through fructification; b. spores; c. basidium. (a x 150, b,c x 700).
- Fig. 3. *C. centrifugum*; a. hypha; b. basidium and spores (x 700); c. section (x 150).
- Fig. 4. *C. pelliculare*; a. incrusted and even hyphæ; b. basidium (x 700); c. section (x 150).
- Fig. 5. *C. investiens*; a. sterile paraphysis from hymenium (x 700).
- Fig. 6. *C. vagum*; hypha and spores (x 700).
- Fig. 7. *Peniophora longispora*; cystidia and spores (x 700).
- Fig. 8. *P. Allescherii*; cystidia and spores (x 700).
- Fig. 9. *P. incarnata*; a. glæocystidia; b. cystidia (x 700).
- Fig. 10. *P. carnea*; a. incrusted cystidia (x 700); b. section showing prominent cystidia (x 64); c. brown, branching paraphyses (x 700).
- Fig. 11. *P. albugo*; spores and incrusted cystidia (x 700).
- Fig. 12. *P. cinerea*; a. glæocystidia; b. spores; c. cystidium (x 700).

Magnifications given above are for the original drawing. For figures on the plate they are one-third less.

PLATE I

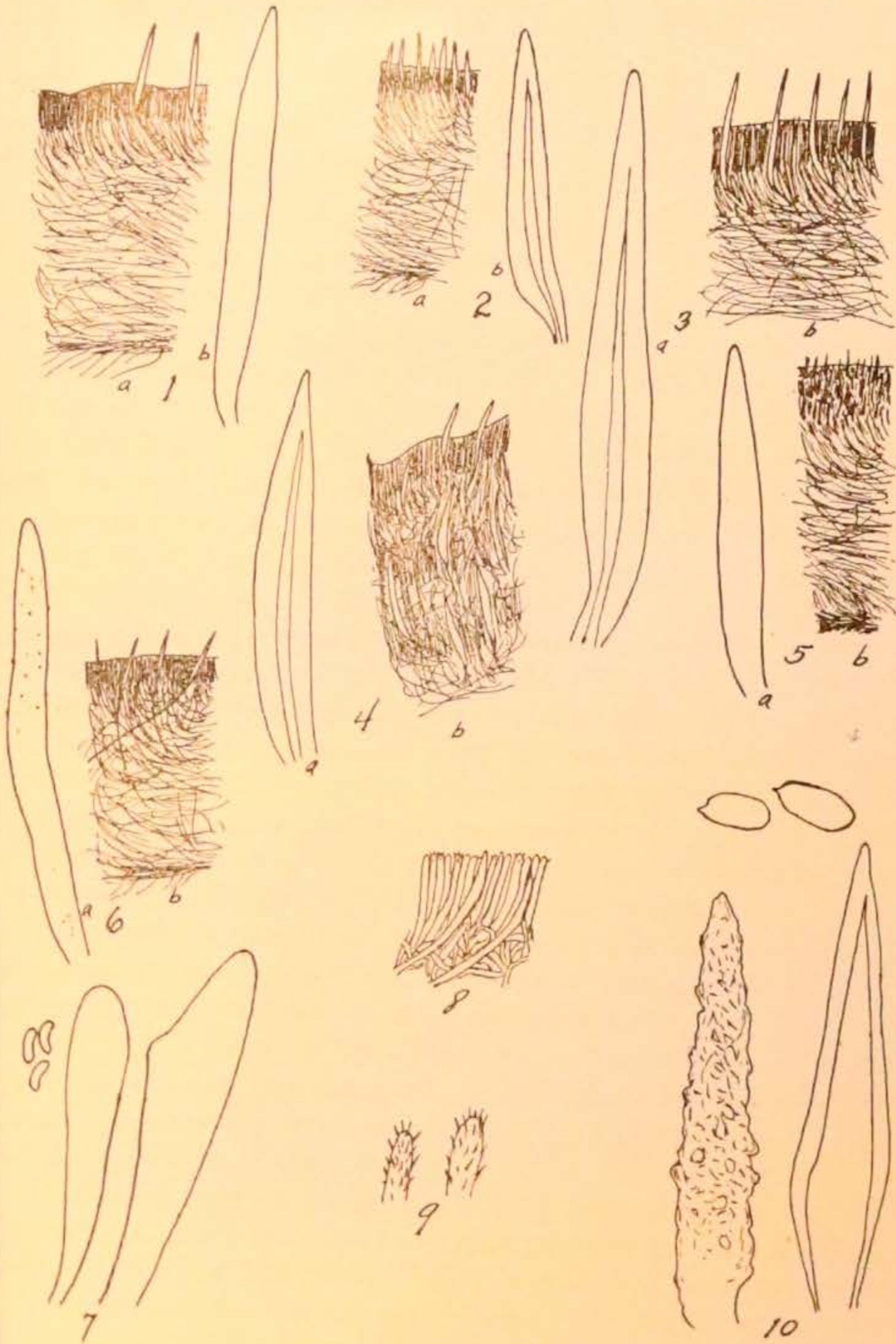


PLATE II

- Fig. 1. *Hymenochaete Curtisii*; a. section through fructification (x 150); b. seta (x 700).
- Fig. 2. *H. badio-ferruginea*; a. section through fructification (x 150); b. seta (x 700).
- Fig. 3. *H. arida*; a. seta (x 700); b. section (x 150).
- Fig. 4. *H. corticolor*; a. seta (x 700); b. section (x 150).
- Fig. 5. *H. rubiginosa*; a. seta (x 700); b. section (x 64).
- Fig. 6. *Stereum umbrinum*; a. cystidium (x 700) b. section through fructification (x 64).
- Fig. 7. *S. rufum*; glæocystidia and spores (x 700).
- Fig. 8. *S. fasciatum*; colorless conducting organs and spiny-tipped paraphyses (x 700).
- Fig. 9. *S. frustulosum*; bottle-brush paraphyses (x 700).
- Fig. 10. *S. cinerascens*; cystidia and spores (x 700).

Magnifications given above are for the original drawings. For figures on the plate they are one-third less.

PLATE II



# NOTES ON THE TREMELLALES OF IOWA, WITH KEYS

G. W. MARTIN and EDNA E. HUBER

The higher Basidiomycetes, represented by the mushrooms and puffballs and their allies, possess simple, non-septate, clavate or pyriform basidia from which, in typical cases, four narrow sterigmata arise directly, each of which bears a single spore. Sometimes the number of spores borne on a basidium is more or less than four, rarely as many as ten or as few as one, and not infrequently, in the Gasteromycetes, the sterigmata are lacking and the spores are therefore sessile. While differing in many minor particulars, such basidia are remarkably uniform as a whole, and are designated as *homobasidia*. In contrast with these basidia are those produced by the lower Basidiomycetes, including the Uredinales (rusts), the Ustilaginales (smuts), and the Tremellales. In these fungi the basidia either arise directly from resting spores, or are septate, or produce the sterigmata only at the tips of special outgrowths arising from the basidia. Commonly two, or all three of these characters are associated in the same species. Such basidia are designated *heterobasidia*. Of the orders characterized by heterobasidia, the Ustilaginales and Uredinales are parasitic and do not form definite fruiting bodies, while the Tremellales are usually saprophytic and bear their basidia on definitely organized basidiocarps.

The Tremellales may be defined, then, as an order of Basidiomycetous fungi characterized by heteromorphic basidia which are produced on specialized basidiocarps and usually borne in a hymenium. While many of the species are gelatinous, some are waxy or coriaceous and were formerly classed among the Thelephoraceæ, from which group it has been necessary to remove them on account of the structure of their basidia.

The order may be divided into four suborders: the Auriculariineæ, the Tremellineæ, the Daeryomycetineæ and the Tulasnellineæ, all but the last named being represented in Iowa. In the Auriculariineæ the basidia are elongate and divided by transverse walls into usually four cells. The suborder is represented in Iowa by the families Auriculariaceæ and Pilacrææ. In the Tremellineæ,

the basidia are subglobose or pyriform and are divided by two longitudinal and intersecting septa into usually four cells, each of which sends out a branch tipped with a sterigma and a spore. The family Tremellaceæ includes a number of Iowa species. In the Daeryomycetinae the basidia are at first cylindrical and remain undivided. At or just below the tip they produce two thick branches, each tipped with a sterigma and a spore. The only family is the Daeryomycetaceæ, which is represented in Iowa by several species. In the Tulasnellinae the basidia are also undivided, but are somewhat pyriform in shape and bear four swollen, spore-like branches, each tipped with a sterigma and a spore. So far as known there are no Iowa representatives. Since the number of families is small, the suborders are disregarded in the keys.

In the preparation of this paper, the standard works of Fries and Saccardo have been supplemented by the excellent treatments of the Tremellales of Wisconsin and North Carolina by Gilbert (5) and Coker (4) respectively, and by the critical notes of Lloyd (6) and of Burt (2, 3). Reference should also be made to the treatment of certain species of this group by Neuhoff (7). Discussion of the questions raised by Neuhoff is deferred for a more technical paper to appear later, but our conception of the group as a whole has been influenced greatly by his views. In deciding upon nomenclature, an attempt has been made to select the most generally accepted name for each species, with adherence to the International Code in doubtful cases. It seems unwise to attempt to supply a list of synonyms in a preliminary account of this sort, but in some instances names which are here regarded as synonyms, but are commonly met with in the literature, are noted.

Of the twenty species here recognized as occurring within the State, one belongs to the Auriculariaceæ, one to the Pilacraceæ, thirteen belong to the Tremellaceæ and five to the Daeryomycetaceæ. Further study will doubtless reveal the presence of a few additional species, but it is not probable that the number will be greatly increased, and it is believed that our list includes all the commoner forms as well as some that are not common.

The gelatinous species of the Tremellales are among the most xerophytic of the fungi, their structure permitting them to absorb water rapidly during periods of wet weather and to form and discharge spores actively, drying up and remaining dormant during the intervening dry periods. Buller (1) notes that fruiting bodies

of *Auricularia mesenterica* may revive, and produce and discharge spores after being kept eight months in the laboratory, and this is probably not an extreme case. This feature is of great advantage in their study. While they dry up into more or less shrivelled masses or even into thin horny films on the substratum, they may be soaked for a short time and will resume their natural shape after years in the herbarium. As the color is apt to fade, however, it is well to note their color in the moist condition when freshly collected.

The Tremellales of Iowa are of little direct economic importance, but as active wood rotting forms they are of significance in the reduction of wood and woody plant parts to humus in forests. Occasionally species belonging to the Daeryomycetaceæ attack structural timbers.

#### KEY TO FAMILIES OF IOWA TREMELLALES

1. Basidia septate .....(2)
2. Basidia elongated, divided transversely into four cells, each cell bearing a single spore .....(3)
3. Hymenium present, spores borne on sterigmata which are often formed at the tips of long branches. Basidiocarp typically gelatinous. ....Auriculariaceæ
3. Spore bearing region enclosed within a pseudoperidium; spores sessile or nearly so. Basidiocarp dry. ....Pilacraceæ
2. Basidia ovate or pyriform, cruciate-septate, each cell bearing a long branch with a sterigma and a spore at the tip. ....Tremellaceæ
1. Basidia simple, cylindrical, forking into two stout branches, each bearing a sterigma and a spore at the tip. ....Daeryomycetaceæ

#### Auriculariaceæ

Basidiocarps variously shaped, waxy to gelatinous when moist; basidia elongate, transversely septate, usually 4-celled, each cell bearing a single spore on a sterigma, the latter sometimes at the tip of a long branch. But one genus occurs in Iowa.

#### AURICULARIA Bulliard

Basidiocarp tough-gelatinous, horny when dry, dimidiate or cupulate, stalked or sessile. Upper surface sterile, tomentose; hymenium inferior, smooth, reticulate or veined, exposed from the first. Basidia slender; clavate or cylindrical, divided into four cells, forming a palisade layer immersed in a gelatinous matrix, each cell sending a long, tortuous branch to the surface, where it

contracts into a sterigma bearing a spore. Spores white, oval, cylindrical, often curved. On wood.

*Auricularia auricula-judæ* (L.) Schroet. (Fig. 1)

This, our only species, is common on dead branches, especially of hickory and oak. The gelatinous basidiocarps have somewhat the shape of a human ear, hence the common as well as the specific name "Jew's-ear." When moist and expanded they vary in color from deep reddish brown to yellow brown, drying nearly black. The spores are allantoid, smooth, white in mass, 12-14 x 4-6 $\mu$ .

### Pilacraceæ

Basidiocarp stalked, capitate. Basidia cylindrical, transversely septate, 4-celled, each cell bearing a nearly sessile spore. Basidia borne in dense clusters, the spore bearing region surrounded by a loosely woven outer layer which dries as a peridium, breaking away at maturity. But one genus occurs in Iowa.

#### PILACRE Fries

Basidiocarp stalked, capitate, dry. Basidia borne in a globose cluster surrounded by a pseudo-peridium. Spores globose, brown, with a thick wall.

*Pilacre faginea* (Fr.) Berk. & Br. (Fig. 2)

Our only species is firm in texture, looking like a little stalked puffball or a large Myxomycete. It is usually from 5 to 7 mm. tall with a head 1 to 3 mm. in diameter. The spores are light brown in color under the microscope, subglobose, but somewhat flattened, mostly 8-10 $\mu$  in diameter. Not uncommon, occurring in dense clusters on rotten oak and *Ostrya* stumps.

### Tremellaceæ

Basidiocarp variously shaped; tough, waxy or gelatinous in texture; basidia pyriform or subglobose, divided by longitudinal septa into usually four cells (cruciate-septate), each of which produces a long branch, tipped with a sterigma and bearing a spore.

#### KEY TO GENERA OF IOWA TREMELLACEÆ

- |  |   |
|--|---|
| 1. Texture gelatinous .....                          | 2 |
| 1. Texture waxy, coriaceous or tough .....           | 4 |
| 2. Texture of basidiocarp uniformly gelatinous ..... | 3 |



2. Texture mostly gelatinous, but including a dense, fleshy central body or membrane ..... *Næmatelia*
3. Spores white, elongate, curved, hymenial surface usually tuberculate; on wood ..... *Exidia*
3. Spores white or colored, broadly oval to globose, hymenial surface smooth; on wood or soil ..... *Tremella*
4. Basidiocarp tough, erect and usually branched, with aspect of *Thelephora*; on ground ..... *Tremellodendron*
4. Basidiocarp tough or waxy; resupinate; hymenium smooth or tuberculate ..... *Sebacina*

#### NÆMATELIA Fries

Basidiocarp gelatinous, but with a non-gelatinous, fleshy central nucleus or an included non-gelatinous membrane. Hymenium covering entire exposed surface. Basidia ovate, cruciate-septate. Spores allantoid, oval or subglobose. We have but one species.

#### *Næmatelia nucleata* (Schw.) Fr. (Fig. 3)

Basidiocarp gelatinous, soft, pulvinate, gyrose, with a tough, fleshy nucleus which becomes prominent on drying, 2-5 mm. in diameter, becoming larger by anastomosis. Color at first pallid or yellowish, becoming cameo brown, often with pronounced vinaceous tints. Nuclear body opaque, yellow. Spores allantoid, colorless, smooth, germinating by budding, mostly 10-11 x 4-4.5  $\mu$ .

On dead oak limbs. Not uncommon.

#### EXIDIA Fries

Fructifications gelatinous, variously folded and convoluted; hymenial surface often characterized by punctate dots. Basidia cruciate-septate; spores hyaline, cylindrical, curved. We have three species, all common.

#### KEY TO IOWA SPECIES OF EXIDIA

1. Basidiocarp white or cream colored when moist; glæocystidia abundant ..... *E. alba*
1. Basidiocarp darker when moist; glæocystidia lacking ..... 2
2. Basidiocarp light to medium brown, composed of flattened lobes, sterile on one side ..... *E. recisa*
2. Basidiocarp dark brown to nearly black, effused gyrose-pulvinate ..... *E. glandulosa*

#### *Exidia alba* (Lloyd) Burt. (Fig. 4)

Basidiocarps gelatinous but firm, forming large convoluted masses, sometimes with a diameter of 25 cm. or more. Color when

fresh, white to pale ochraceous, becoming russet brown on drying. Hymenium covering entire exposed surface. Basidia subglobose or oval, cruciate-septate, interspersed with numerous cylindrical or swollen glæocystidia, the latter with dense granular contents. Spores hyaline, kidney-shaped, 8-11 x 4-5  $\mu$ .

Common throughout the State, occurring in large masses on dead wood of various sorts, especially cottonwood and willow. *Seismosarca alba* is a synonym.

*Exidia recisa* Dittm. ex Fr. (Fig. 5)

Basidiocarps gelatinous, rather soft, forming irregular clusters on wood, up to 10 cm. long. Lobes flat, thin, sterile on upper surface which is dotted with fine points which appear as crustose flakes under the microscope. Hymenium inferior, smooth. Color light brown, becoming darker when old and nearly black when dry. Basidia subglobose, cruciate-septate; spores hyaline, allantoid, 10.5-14 x 3-5  $\mu$ .

On dead wood, extremely common. *E. gelatinosa* is a synonym.

*Exidia glandulosa* Bull. ex Fr. (Fig. 6)

Basidiocarp gelatinous and soft, forming flattened, gyrose cushions, usually elongated and frequently coalescing into masses 10 to 15 cm. in length. Entire exposed surface fertile, finely but noticeably punctate. Color very dark brown, drying as a thin, horny, black layer. Basidia pyriform, cruciate septate; spores colorless, smooth, allantoid, 8-16 x 3-5  $\mu$ , sometimes larger.

On dead limbs of various frondose trees. Common. The dark color and the minute tubercles on the hymenium are distinctive.

TREMELLA Dill. ex Fries

Basidiocarp gelatinous, soft to rather firm, variously shaped, in our species foliaceous, cerebriform or erect with thick branches. Hymenium covering entire exposed surface, smooth. Basidia cruciate-septate. Spores globose, broadly elliptical or pear-shaped, white or colored. Mostly on wood, a few species on the ground.

KEY TO IOWA SPECIES OF TREMELLA

1. On the ground; erect, with thick branches, white or cream colored .....  
.....*T. reticulata*
1. On wood; sometimes lobed, but not branched .....2
2. Dark brown; large, with many flattened lobes .....*T. frondosa*
2. Orange or yellow .....3

3. Rather large, pulvinate-cerebriform, not hollow .....*T. mesenterica*  
 3. Smaller, lobed, the lobes few in number; hollow, vesicular .....  
 .....*T. lutescens*

*Tremella reticulata* (Berk.) Farl. (Fig. 8)

Basidiocarp gelatinous, rather firm and elastic, arising from the ground as erect, branched, self-supporting clusters of hollow whitish finger-like lobes, which are more or less fused together. Usually rather large, sometimes forming clusters 10-12 cm. in diameter. Spores hyaline, smooth, oval, 9-11 x 5-6  $\mu$ .

Very common in Eastern Iowa.

*Tremella frondosa* Bull. ex Fries. (Fig. 9)

Fructification gelatinous, rather tough, composed of numerous thin, contorted, leaf-like lobes arising from a flattened, stem-like base. Masses rather large, up to 12 cm. in diameter. Color tawny to russet when fresh, becoming darker with age, and drying nearly black. Hymenium smooth, covering entire free surface. Spores white, smooth, spherical to broadly oval, 7-9  $\mu$  in diameter.

Frequent on oak stumps.

*Tremella mesenterica* Retz. ex Fries. (Fig. 7)

Basidiocarp 3-4 cm. long, 2-3 cm. wide, gelatinous, soft when wet, but firm and retaining its shape when partly dry; gyrose-pulvinate with numerous thin lobes, not hollow. Color orange to capucine yellow, drying deep orange brown. Basidiospores oval, apiculate, sometimes slightly curved, 12-14 x 8-10  $\mu$ , faintly tinged with yellow in mass. Conidia abundant, borne on branched conidiophores with or a little before the basidiospores, subglobose, yellowish, 3-6  $\mu$  in diameter.

On frondose wood. Apparently not common.

*Tremella lutescens* Pers. ex Fries

Basiliocarp gelatinous, rather firm, forming hollow capitate lobes arising from a restricted stem-like base, 1-3 cm. tall and about the same in width. Color pale orange, drying orange brown to nearly black. Basidiospores white, smooth, globose or broadly oval, 6-9  $\mu$  broad.

On dead frondose wood. Not common. The bright color and hollow lobes are characteristic. Coker expresses doubt whether *T. mesenterica* and *T. lutescens* are distinct, but the two forms referred to these species here are certainly different.

## TREMELLODENDRON Atkinson

Basidiocarp tough, erect, stipitate and branched, rarely simple. Basidia cruciate-septate, spores white. Growing on ground. Fungi with the habit and consistency of *Thelephora*, but with smooth, white elongate spores and tremellaceous basidia. We have two common species, which may be distinguished as follows:

Fructification stout, branches rather thick, often flattened and more or less grown together ..... *T. candidum*  
 More slender; branches numerous, thin, terete, closely intermingled, but not grown together ..... *T. merismatoides*

*Tremellodendron candidum* (Schw.) Atk. (Fig. 11)

Basidiocarp tough, erect, with numerous branches, these sometimes nearly terete and only slightly fused with each other, varying to forms in which the branches are greatly flattened with the outer layers almost completely fused, forming a series of irregular, concentric rosettes. Color white or pallid, becoming buff in old specimens and on drying. Spores colorless, entire, cylindrical or oval, sometimes slightly curved, 7-12 x 4.5-5  $\mu$ .

On the ground in woods. Extremely common in eastern Iowa. Burt segregates the larger forms with fused, flattened branches as *T. pallidum*, restricting *T. candidum* to the forms with cylindrical and separate tips. We find a complete series of forms connecting the two extremes and therefore follow Coker in uniting them all under the older specific name. *Thelephora schweinitzii* is a synonym.

*Tremellodendron merismatoides* (Schw.) Burt

Basidiocarp tough, erect, with numerous slender branches, these mostly terete or angular, only slightly fused, and that near the base. Color pallid when fresh, drying deep buff or brownish. Spores colorless, entire, oval, 8-10 x 4.5-5  $\mu$ .

Less common than the preceding species, but growing with it in the same habitat. Coker expresses doubt whether it is really distinct, but we find no intermediate forms. Coker's illustrations of *T. merismatoides* strongly suggest young, undeveloped specimens of what we regard as *T. candidum*.

## SEBACINA Tulasne

Resupinate, on dead wood or encrusting living woody or herbaceous stems, sometimes on the ground. Texture coriaceous, waxy or somewhat watery when fresh, but never truly gelatinous. Basi-

dia cruciate-septate. Spores colorless, usually oval or elongated. Fungi with the aspect and texture of *Corticium*, but with tremella-ceous basidia.

### KEY TO THE IOWA SPECIES OF SEBACINA

1. Subfleshy, growing on the ground and encrusting living stems and debris .....*S. incrustans*
1. Growing on dead wood .....2
2. Cacao brown when dry; hymenium not tuberculate .....*S. deglubans*
2. Ashy white when dry; hymenium somewhat tuberculate .....*S. calcea*

#### *Sebacina incrustans* (Fr.) Tul.

Basidiocarp subfleshy, resupinate, creeping over ground and encrusting debris, the bases of stems of living plants and the bark at the base of trees, sometimes forming small erect branches, whitish, becoming buff when dried. Usually 4-5 cm. in length, frequently much larger. Basidiospores colorless, smooth, oval or slightly curved, 12-14 x 6-8  $\mu$ .

Common in woods.

#### *Sebacina deglubens* (B. & C.) Burt

Basidiocarp resupinate, separable, white beneath, clay color when moist, becoming cacao brown when dry. Margin white, cottony. Hyphae of hymenium little differentiated from those of the interior. Basidiospores hyaline, 8-9 x 3.5-5.25  $\mu$ .

On dead wood. Rare.

#### *Sebacina calcea* (Pers.) Bres. (Fig. 12)

Basidiocarp effused, waxy, drying crustaceous, closely adnate to substratum and not separable; up to 6 cm. in length and 1.5 cm. broad. Dull white when fresh, drying ashy to tulleul buff with a narrow whitish margin. Spores simple, hyaline, cylindrical, slightly curved, 14-16 x 6-8  $\mu$ .

On dead wood, mostly willow. Not uncommon in northwestern Iowa.

### Dacryomycetaceae

Basidiocarps pulvinate, cup-shaped, spathulate or fusiform, usually rather small; gelatinous, tough-gelatinous or cartilaginous, drying hard; usually orange or yellow. Basidia simple, at first cylindrical, but forking into two thick branches at or just below the tip, each branch bearing a sterigma and a spore, the mature

structure having a characteristic forked appearance. Spores smooth, cylindrical, curved, dividing into two or more cells before germination.

#### KEY TO GENERA OF IOWA DACRYOMYCETACEÆ

1. Basidiocarps sessile, pulvinate, gelatinous ..... *Dacryomyces*
1. Basidiocarps with a distinct stalk, somewhat tough ..... 2
  2. Erect, slender, simple or branched, hymenium amphigenous..... *Calocera*
  2. Erect; spathulate, cup-shaped or applanate; hymenium restricted to one surface ..... *Guepinia*

#### DACRYOMYCES Nees ex Fries

Basidiocarp gelatinous, sessile, but often attached by a central, rooting stalk; pulvinate, the surface usually convoluted. Basidia becoming fureate, spores allantoid, hyaline, becoming septate before germination.

We have two species, one very common, which may be separated as follows:

- Cinnamon to cinnamon-buff when moist, drying reddish ..... *D. ellisii*  
 Antimony yellow when moist, drying vinaceous russet ..... *D. deliquescens*

#### *Dacryomyces ellisii* Coker (Fig. 14)

Basidiocarps gelatinous, pulvinate, but usually arising from a thick, more or less rooting stem. Exposed surface wrinkled, entirely fertile, 1-6 mm. in diameter, becoming much larger by coalescence; cinnamon to cinnamon-buff when moist, drying reddish. Spores hyaline, oval, slightly curved, at first simple, becoming 4-celled, 11-13 x 5-6  $\mu$ .

On deciduous wood, Okoboji region. Apparently not common.

#### *Dacryomyces deliquescens* Duby. (Fig. 13)

Basidiocarp gelatinous, subglobose, from a more or less rooting base, appearing pulvinate, 1-3 mm. in diameter, sometimes coalescent. Antimony yellow when moist, drying vinaceous russet or darker. Spores oval, 10 x 5.5  $\mu$ .

This seems to be *D. deliquescens* in Burt's sense, but the species referred to *D. minor* Pk. by Coker.

Common, on native deciduous wood and on coniferous planks.

#### CALOCERA Fries

Basidiocarp erect, simple or branched, slender fusiform, all parts except the basal stem covered by the hymenium; tough-gelatinous,

viscid; orange or yellow. Basidia forked, spores smooth, allantoid, dividing into two cells before germination. On wood. Resembling small species of *Clavaria*, but distinguished by their texture and by the nature of their basidia. We have but one species.

*Calocera cornea* Fr. (Fig. 15)

Basidiocarp erect, slender fusiform, simple or somewhat branched, caespitose and often anastomosing at the base and extending in long lines from a crack in a log. Pale yellow when moist, becoming darker upon drying. Spores cylindrical, slightly curved, dividing into two cells before germination, 9-10 x 4-4.5  $\mu$ .

Common on deciduous wood, especially on large decorticated trunks.

GUEPINIA Fries

Basidiocarps stalked, subgelatinous, tough, flattened, spathulate, applanate or cup-shaped, with hymenium restricted to one surface. Basidia forked. Spores suballantoid, hyaline, dividing into two or more cells before germination. We have two species.

Color orange or yellow; spathulate ..... *G. spathularia*  
Color dark brown; cup-shaped or applanate ..... *G. elegans*

*Guepinia spathularia* Fr. (Fig. 17)

Basidiocarps erect, spathulate, caespitose, often extending in long lines from cracks in wood. Hymenium restricted to one side of the flattened upper part. Orange yellow when moist, the hymenium drying darker than the sterile surface. Spores smooth, hyaline, elliptical, curved, 7-9 x 4-4.5  $\mu$ , dividing into two cells before germination.

Rather common on decorticated deciduous logs. When well developed, the hymenial surface is very distinctly inferior and is marked by vein-like ridges, as in *Cantharellus*.

*Guepinia elegans* B. & C. (Fig. 16)

Basidiocarp gelatinous-tough, stipitate with a flattened applanate or somewhat cupulate pileus, the outer side sterile, the hymenium restricted to the inner surface; 1-2 cm. high, caespitose, occasionally branched. Stipe terete, tomentose. Color deep reddish brown, drying blackish. Spores elliptic, somewhat curved, 12-16 x 6-7  $\mu$ , becoming 4-celled.

On dead elm logs and stumps. Not uncommon.

## PLATE I

All drawings made with camera lucida and reduced to a magnification of 500 diameters in reproduction.

Fig. 1. *Auricularia auricula-judæ*. Immature basidium and three basidiospores.

Fig. 2. *Pilacre faginea*. Immature and mature basidia with basidiospores.

Fig. 3. *Næmatelia nucleata*. Four immature basidia, two with the branches developed; two spores on sterigmata and five detached basidiospores, two of which are germinating.

Fig. 4. *Eridia alba*. Above, diagrammatic section through hymenial region, showing glæocystidium; below, enlargements on glæocystidia and five basidiospores, three of which are germinating, one of these producing a secondary spore.

Fig. 5. *Eridia recisa*. Four basidiospores.

Fig. 6. *Eridia glandulosa*. Six basidiospores, all from same basidiocarp.

Fig. 7. *Tremella mesenterica*. Conidiophore with conidia; two basidia; portion of basidial branch with sterigma and spore at tip; four ungerminated basidiospores and two germinating basidiospores with secondary spores still attached.

Fig. 8. *Tremella reticulata*. Basidia and basidiospores.

Fig. 9. *Tremella frondosa*. Basidia and basidiospores.

Fig. 10. *Tremella lutescens*. Basidia and basidiospores.

Fig. 11. *Tremellodendron candidum*. Basidium and five basidiospores, one germinating.

Fig. 12. *Sebacina calcea*. Four basidia and six basidiospores, one germinating.

Fig. 13. *Dacryomyces deliquescens*. Three immature basidia and basidiospore.

Fig. 14. *Dacryomyces ellisii*. Two basidia, one immature, one collapsing after discharging spores; three basidiospores, one germinating.

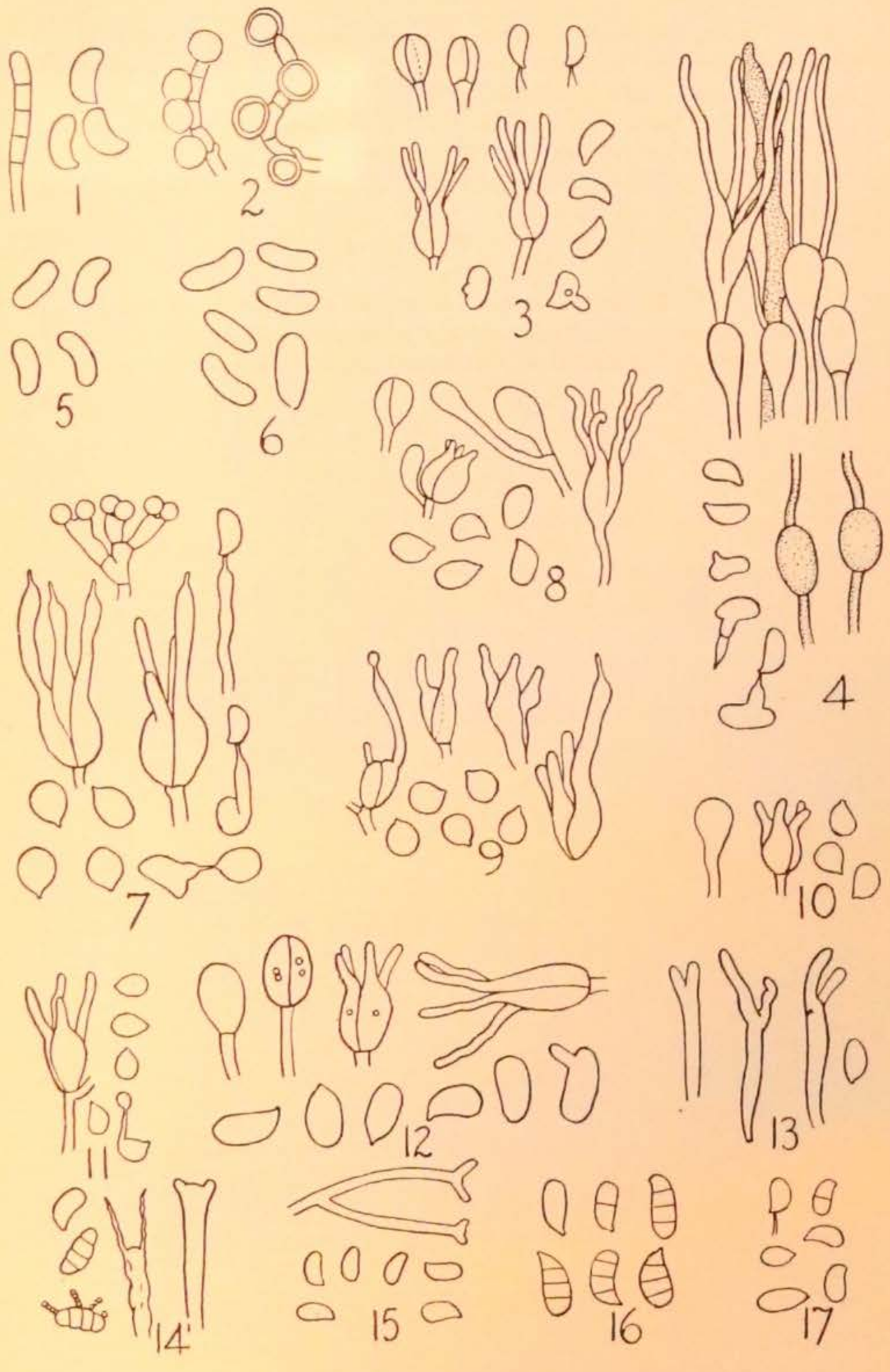
Fig. 15. *Calocera cornea*. Immature basidia and basidiospores.

Fig. 16. *Guepinia elegans*. Six basidiospores.

Fig. 17. *Guepinia spathularia*. Six basidiospores, one still attached to sterigma.



PLATE I



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