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THE PYRENOMYCETES OR BLACK FUNGI OF IOWA

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The Pyrenomycetes constitute a large and generally well marked section of the Ascomycetous Fungi. If we omit here the Perisporiales as an order by itself we may say of the Pyrenomycetes that there are perhaps 10,000 species, grouped in many genera, families, etc., but generally all set out in three suborders, the Sphariales, Dothideales and Hypocreales. The first two suborders named include by far the greater number of species and are in fruiting black, Pyrenos proper; the third suborder, the Hypocreales, have fructifications corresponding in structure to true Pyrenos but in color assume various tints red, yellow, etc., never black.

As other organisms fungi are classified according to their fruits: in this case by their method of spore production. Two main divisions of the Fungi are the Basidiomycetes, which bear their spores on little stalks or bases, as in the mushrooms, and the Ascomycetes, which bear their spores in little sacs. Of these we have chosen the Ascomycetes for study. Since these form such a very large group, nearly half of all the fungi that have been described, we choose for the present paper only a single section known as the Pyrenomycetes and of these only those found in Iowa.

The Ascomycetes possess one character which distinguishes them from all other fungi and that structure is the ascus, the peculiar sac in which the spores are borne. It is regrettable that this character is microscopic since some of the sacs are singularly attractive in shape and color. In many cases they are so small that it takes careful attention to prove their existence at all. The word Pyrenomycetes signifies the fact that most of these plants are dark-colored or black. Pyreno comes from a Greek word meaning charred or burned. The ending mycetes is the Greek equivalent for fungus. In the Pyrenomycetes furthermore, the asci or spore-sacs are enclosed in chambers or flasks and are thus distinguished from the Discomycetes, whose asci are borne in open, oftentimes bright colored fleshy receptacles, cups or concave disks. These receptacles are called perithecia. The perithecia are lined inside and at the base with a hymenial layer which gives rise to the asci and their asso-

ciate structures, the paraphyses. The asci are occasionally preceded by a nuclear fusion which suggests a sexual process. I note that in some Pyrenos the fructification, including the asci, follows the stimulus apparently of sexual reproduction, at least of nuclear fusion. This is notable in some of the Erysibaceae, a group of leaf parasites. In any case the asci are developed similar to homologous organs of some of the higher algae where sexuality is the exciting cause. The spores are generally eight in each ascus and escape from the perithecium through an opening in the top of the flask called an ostiolum or mouth. When water is absorbed one ascus after another elongates and ejects spores or they may be pressed out of the perithecium in a swollen mass. The simplest of the Pyrenomycetes possess perithecia which grow on an inconspicuous mycelium, as the Nectrias and Sphaerias. In other forms the perithecia are in clusters seated in a cushion or branching mass of modified hyphæ called the stroma.

Valsa lupini Cke. and Hark. was selected for a simple developmental study. When put in water Sept. 30, 1921, at 6 p.m. it looked like a bit of colored gelatin. By 10 o'clock the next morning a small globule had pushed up from beneath the bark of the host plant and looked like a bit of semitransparent jelly. At seven-thirty the next morning the globule was about the size of a pea and was becoming fuscous: at ten-thirty there were milky white specks dotting the whole outer surface, which had become darker and was beginning to shrivel: by six o'clock that evening the surface was jet black and still translucent, with deep wrinkles, and the white specks were more distinct; from this on there was little change in size. A slide showed numerous hyphal threads, a few of them on the outer surface sooty black and finely circinnate. The corrugations became deeper till the botryoid fructification took final form; then the external part collapsed and we had the hard rugulose, spiny exterior of the forming perithecia with here and there a long milky white hyphal thread woven over the top. Gradually the several perithecia took shape and separated and thus the whole mass was split up. The rough tubercular appearance of the perithecia with their prominent ostiola indicated their number in each stroma.

On exposure to the air the wrinkled exterior of each perithecium became tough and hard, enclosing transparent protoplasm which showed here and there differentiating centers but remained jelly-like. The milky white specks were evident till the plant took on its final black appearance and its growth was completed. The interior hyphæ were undifferentiated for six weeks, when at last a slide

indicated that asci and paraphyses were forming and at the end of two months asci were formed and contained the spores.

The aim of this study was merely to state the facts, which probably are typical of the history of many of the forms here listed. Since as we shall see some members of this group cause each year great disturbances among our economic plants, it is evident that the knowledge of the life habits of the fungi is of fundamental importance in combating their progress. It appears that the same fungus is not equally virulent on all forms of its hosts. Such varieties as are now resistent should be chosen for cultivation. But not even all the individuals of the same variety have the same resistance.

There is great diversity of fructification among members of this group. The fruiting bodies are spherical, elongate, flattened or oblong; some swollen and irregular in shape. They vary also in color, for while as was said the leading orders, Perisporiales, Dothideales and Sphaeriales are all black forms, the fourth order, Hypocreales, often shows bright tinted fructifications, red, yellow, green, etc. Nectria, a Hypocreal type, plagues apple trees and currant bushes and occurs everywhere on dying or dead twigs of the black oaks. The ostiola vary from an inconspicuous pore to a beak or an elongated slit, as in the Hysteriaceae. The spores vary in shape from simple elliptical to fusiform in structure, from uniseptate to pluriseptate; even muriform are they; and in tint from hyaline to yellow to dark brown. The number of septa varies even in the same species, more septa being found in the first spores produced and often fewer at maturity as the energy of the plant decreases.

The Pyrenomycetes which are now causing the most economic disturbances have not only definite ascospores but show also abundant conidia, spores of both sorts often appearing on the same slide. One soon observes that there is in most cases a not inconsiderable range of spore dimensions in a given species so that a small discrepancy between the measurements cited and those found in a specimen at hand, may not, other things not being inconsistent, forbid supposed identity. There has been much systematic study on these fungi, but not until the disease producing activity of some has been understood, especially during the last few years, have they become more generally investigated. From the standpoint of our personal health and wealth, i.e., from an economical standpoint, it is evident these invaders should be studied; for they come among us unawares like an invading army and work night and day till they completely devastate their hosts.

Persoon, Bulliard and Fries were pioneer mycologists. In recent years Saccardo's "Syloge Fungorum" coming out in twenty-two volumes, in Italy, may be taken as an index of the scientific interest in the general subject; while the fact that of this large work the first two volumes are given over to the Pyrenomycetes shows the relative importance of the groups.

Almost any locality may produce fungi provided the right conditions prevail to give them a chance, but the low places along the streams in Iowa are especially productive and material can be found in the undisturbed woods at all seasons of the year. However, it is sometimes difficult to get specimens in just the right stage for study. Often the material is immature or it may be too old. Certain species produce spores which are very evanescent and even a good collector is apt to miss the stage which will be necessary for the correct identification of his specimens. Not a few mistakes are therefore recorded, because the student has failed to obtain all the stages in the development of the plant. Some of the Pyrenomycetes as stated have two kinds of spores; they have of course the spores in sacs, or ascospores, and also spores of a much simpler kind, simply small cells or conidia, cut off from the hyphæ of the growing plant and capable of reproducing it. Accordingly we say that a given Pyrenomycete, or "Pyreno" as we may say for short, shows two phases, a conidial and an ascophorous, the latter enduring through the winter months, the former beginning its development in the spring, the summer phase. For instance, the conidial stage of *Fuscicladium dendriticium* (Wallr.) Fckl. was long known on apple leaves and fruits; classified under the Imperfecti for years; later the ascophorous stage, *Venturia inaequalis* (Cke.) Wint. of the same fungus, was discovered, and both phases are now classified under the latter name with the Ascomycetes. Many of the Imperfecti may in time be proven thus to belong elsewhere; it remains to discover and connect up such relationship. The stage representing the sexual phases may be obscure or wanting for the time being, as the plant may have used up all of its energy in producing conidia, and for economy's sake since it is insured of reproduction through its conidia, the plant may postpone the next cycle of development until strong enough to produce the ascospores. And so one may find a certain fungus growing to-day, and may search for the same thing for years and never see it again. It would seem that there is often a lapse in certain fungi; they fail of all regularity. Only when conditions are favorable do they have a complete life-history.

One or two new species have been reported and described from these collections. It is the aim in this study to illustrate the gross characters and microscopic details of fructification. Where possible the ascus and spores have been drawn, but in a few cases an imperfect specimen or similarity to another species or lack of space on the plate has limited us and only spores have been drawn. Drawings of natural conditions are as exact as possible, but no attempt has been made to draw asci to the same scale, they are drawn to a scale which will give the most instructive presentation. Gross characters were studied with the dissecting microscope and the low power of the compound microscope was often used with advantage. Reagents have been used which keep the organs of normal size so that exact measurements could be taken. A saturated solution of iodine was used as a stain where the spores were hyaline and were seen with difficulty. Color changes during growth have been recorded in the descriptions, where they have been observed. In recording size of spores and asci several were measured and the average size was recorded in microns, designated as usual by the Greek character μ. Measurements in millimeters or centimeters are so indicated. The descriptions are made from the specimens in hand and in most cases follow Saccardo. Notes on the general appearance and distinguishing marks are added below the translation from the Latin. In giving the synonymy of the species those references which are to be consulted at the State University are given and such citations as are needed to give proper credit to the author of the particular specific name adopted.

This study of plants which are commonly found around us was begun in 1906. Collections by Dr. Charles L. Smith and by Prof. Morgan are to be seen in the Herbarium. Other collections have been made since. All the specimens from the states of Washington and California and some from Iowa were collected by Dr. T. H. Macbride, who has been of constant assistance throughout this study. Some were brought in by Prof. B. Shimek, the *Leptosphaeria artemisia* (Fckl.) Auersw. from Idaho was collected by Prof. R. B. Wylie and many from Black Hawk, Johnson and Grundy counties were collected by the writer.

CEDAR FALLS.