Middleton Fungi*.—By R. R. Gates, M. A., *Middleton, N. S.*

(Read 8th September, 1902)

The study of our Fungi is a part of botanical science to which comparatively little attention has hitherto been directed by Canadian botanists, so that Canada is reckoned as one of the regions which is still mycologically unexplored. The absence of chlorophyll, which has been brought about by the parasitic and saprophytic habits of these plants, distinguishes them from all other members of the plant kingdom; and perhaps on this account, being considered as the degenerate and depauperate representatives of a once higher type, they have been accounted of less scientific interest and economic importance than the chlorophyll-bearing plants.

Investigations of recent years have shown that a relation exists between the mycelium of fungi in the soil, and many of the higher plants. Widely occurring instances of mycorrhiza are known. Thus Janse found that out of seventy-five plants selected at random and examined, sixty-nine had mycelial hyphæ attached to their roots. These hyphæ had replaced the root hairs, root cap, and in some instances the outer layer of the root tissue. Their advantage to the plant over root hairs seems to be a matter of osmotic pressure in facilitating absorption.

We also have among Chlorophytes, examples of plants which are being still further reduced, so that the whole root has been replaced, the chlorophyll of the leaves being reduced in amount, and the whole plant becoming incipiently saprophytic. This has been called Symbiotic Saprophytism, and the isolated tropical

* This paper was read in the absence of the author by the Corresponding Secretary of the Institute, Dr. A. H. MacKay, who presented a large number of dried specimens, and the compilation of lists of Nova Scotia fungi, which appears on page 122 of this volume, with which is consolidated the list of about forty fungi determined by Mr. R. R. Gates, from the vicinity of Middleton, Annapolis County, Nova Scotia. Readers are therefore referred to Dr. MacKay's list for Mr. Gates' catalogue of species. The introductory portian only of Mr. Gates' paper appears here, as it forms a useful introduction to Dr. MacKay's synopsis.

Lycopod, *Psilotum*, which has no true roots, and whose leaves are greatly reduced, furnishes an example. In the common Indian Pipe, *Monotropa uniflora*, owing to parasitic habits still further reduction has taken place, the chlorophyll being entirely lost.

Thus we have plants which feed holophytically, *i. e.*, obtain their nourishment wholly from inorganic materials by absorption through their roots as well as by the activity of their chlorophyll in manufacturing carbohydrates from the carbon dioxide of the atmosphere. These, of course, constitute the great mass of plants. But as we have seen, owing to the absorption of organic compounds ready prepared, by means of mycorrhiza, or on account of parasitism, the chlorophyll of a plant may be gradually reduced in amount until it finally disappears, being no longer necessary.

A similar process has taken place in the evolution of the Fungi, except that they have probably been derived from the simpler Algæ. But the evidence of the reproductive methods shows that this process of loss of chlorophyll and consequent saprophytism probably went on simultaneously in several groups of Algæ. Thus the Fungi do not constitute a single homogeneous group; but their origin has been polyphyletic.

The lowest group of Fungi, the Phycomycetes, on account of their method of sexual reproduction, are believed to be descended from the siphoneous Algæ, probably from a type allied to Vaucheria. There is, however, a great variety in the methods of both sexual and asexual reproduction in this group; but all have probably originated from the Chlorophyceæ. The Ascomycetes on the other hand shows traces of descent from the Rhodophyceæ, the evidence for which need not be presented in a simply introductory statement.

The third great group of Fungi, the Basidiomycetes, including our common mushoooms and toadstools, are generally regarded a having lost all trace of a sexual reproductive process. Certain nuclear fusions which take place during the formation of the

basidium, and its basidiospores have been regarded as sexual. Strasburger objects to this view, regarding the process as merely a nutritive one, stimulating development. He holds that a second essential of fertilization is the union of *diverse* ancestral qualities, and this cannot take place between nuclei so nearly related.

Thus the question of the origin and relationships of the Basidiomycetes still remains obscure owing to their having lost a sexual method of reproduction, although in the structure of the fructification, (*i. e.*, the part bearing asexual spores), they are by far the most highly developed group of the fungi.

Brefeld and his school regard the whole class of fungi as a single one, deny the sexuality of the Ascomycetes, and derive both Ascomycetes and Basidiomycetes from the Phycomycetes. Recent investigations are, however, opposed to these views, as it has been shown that the formation of spores in the ascus by free cell formation is essentially different from the method of spore formation in the Phycomycetes.

Economically, two of the most important orders of the Basidiomycetes are the Ustilagineæ and Uredineæ. These are the cause of the destructive "smuts" and "rusts" on cereals; but they cannot be discussed further here, although their life history is of the greatest interest.

The group of Basidiomycetes which comprises the so-called higher fungi, our mushrooms and toadstools, is the *Hymenomycetes*. They are both parasitic and saprophytic, and their mycelium is widely spread in dead and living plants and in soils.

The leaf mould of our forests is permeated with it; and every fallen log is preyed upon by series of fungi in addition to the action of bacteria and weathering processes, until it is finally reduced to a shapeless mass and mingled with the soil, there to add its share to the nutritive material upon which the saprophytic fungi in the soil subsist.

The spores of parasitic fungi, or "wound parasites," as they are often called, when blown by the wind alight upon a spot on

a tree where the cambium has been broken, and germinate. Wounds of the cambium may be caused by the natural shedding of the lower limbs of a tree, by fires, by windfalls, or in other ways. In all these cases while the wound is being slowly healed over by the growth of the cambial layer it affords an excellent place of entrance for these "wound parasites." When a spore has lodged and germinated, the mycelium at once proceeds to permeate the tissues. It may continue its growth until it has ramified throughout the heart wood, and will then in some species begin its attack upon the sap wood until it has finally permeated the whole tree.

The mycelium generally grows in three directions along definite lines:—vertically, radially and tangentially. By withdrawing the moisture content from the wood it causes shrinkage, and thus the wood is broken up into tiny cuboidal blocks. This is the "doty" stage, and the tree may become so weakened as to fall a prey to wind storms which frequently "check" the heart wood. In the radial lines caused by these "checks" the mycelium in some species will grow abundantly, forming "punk."

The tree cannot resist the growth of the mycelium. Once it has found an entrance it will continue its growth slowly for many years, in some cases for a century. But the tree thus attacked is soon rendered useless for timber, and ultimately must fall. The mycelium generally continues its encroachments upon the cambium, and finally breaks out in fruiting bodies on the surface. These are the shelving hard woody fungi so frequently seen on the trunks of infected trees. The majority of these wound parasites belong to a family of Hymenomycetes known as the Polyporaceæ, characterized, as the name implies, by the presence of numerous pores on the under surface of the hymenophore.

The study of mycology then, has a very important bearing upon the science of forestry. Canada may well consider this study one of prime importance, as affording a scientific basis for helping to solve the problem of the preservation of our vast forest resources. Surely no more practical subject can engage the

attention of any one than aiding in the determination of the best means of combatting these parasitic fungi, which are destroying thousands of dollars worth of timber annually. This cannot be accomplished without a study of the life-history of these plants, their manner of entrance and the stages of their development in the tissues of the tree.

Perhaps a certain feeling of revolt at being engaged in collecting Toadstools and Puffballs, as they are commonly called, nearly all of which are generally regarded as poisonous, has deterred some from becoming mycologists. But after the first introduction to this enticing field of work the interest grows apace. The distinctions between species are often extremely perplexing, and perhaps there is no better training in keenness of observation than the determination of fungi. The great mycologist Fries has remarked that species often appear to be grouped around other species as satellites, and the various gradations of relationship which seem apparent on examination of closely similar species, is often striking.

The main characters made use of in the determination of species of Hymenomycetes are the size and shape of the fructification or hymenophore, and the particular characters of its parts. Some of these characters are the fleshy, fibrous or cartilaginous structure of the stem, whether hollow, solid, fragile, compact, spongy, etc.; of the cap or pileus, the color and shape, whether viscid, glutinous or dry, with or without a pellicle, squamulose, warty, areolate, hairy, tomentose, smooth, etc.; of the gills in the Agaricaceæ, whether adnate to stem, adnexed, free or decurrent, broad or narrow, etc. The presence or absence of an annulus on the stem, and a volva or veil, are also important generic characters. The gills of the agarics are replaced in Polyporaceæ by pores, in Hydnaceæ by spines, in the Thelephoraceæ and Clavariaceæ by a smooth hymenium or spore-bearing surface.

The trama, or interior portion of the gills, exhibits one of two characteristic appearances in cross section under the microscope. In most genera the trama is floccose, consisting entirely

of filamentous hyphæ, but the genera *Russula* and *Lactarius* have a vesiculose trama in which numbers of the hyphal branches have swelled out, forming vesicles intermingled with the filamentous hyphæ. Several genera also possess latex tubes, but these are especially well developed in the genus *Lactarius*, in which a wound causes a copious flow of "milk." This milk may be white, yellow, orange, blue, etc., or may change color on exposure to the oxygen of the air. Many species of *Lactarius* are edible and the flavor of *L. deliciosus*, which has a bright orange milk, may be inferred from its name.

The color, odor and taste of the flesh is also frequently of importance. Some genera and species are characterized by the presence of sterile cystidia and paraphyses in the hymenium, together with the club-shaped basidia which bear the spores. Four spores are usually borne on each basidium.

Thus there is a great deal of variety in the structure of the hymenophore. The spores also frequently show differences of specific value. The genera of the Agaricaceæ are generally placed in five groups, having respectively, white, pink, brown, purple-brown, and black spores. The shade and depth of color, however, vary a good deal within each group. The size, shape, and marking of the spores are also of specific importance. They may be globose, elliptical, oblong, smooth, echinulate, warty, etc., and are only microscopically visible. Their color is easily seen when they fall in quantity or any good back ground, such as white or colored paper with the proper contrast.

In regard to the various mycelia, comparatively little has yet been done to determine specific or generic characters, and perhaps in most cases none such exist. In some species, such as *Armillaria mellea*, Vahl., an agaric parasitic upon certain conifers and frequently found growing from stumps, the mycelium collects into numerous parallel strands, forming cords, the exterior of which becomes blackened with age. These are called Rhizomorphs. They may often be found as blackened cords under the bark of old trees or stumps, and were formerly considered separate fungi, and called *Rhizomorpha subcorticalis*

Sclerotia are similar brownish bodies formed on the mycelium for the purpose of resisting the effects of dry conditions. Generally, however, the vegetative mycelium consists merely of irregularly branching septate hyphæ, which in parasitic species send haustoria into the living cells of the host, and absorb their contents. Thus the mycelium affords very few characters for determination, and in the present state of our knowledge very few species can be recognized from their mycelia.

Another difficulty of determination is the great amount of variation frequently found within a species, making it almost impossible to accurately determine its limits. The color, size and shape of almost any part of the hymenophore may vary, so that the plant may be recognizable only by its general habit and by certain distinctive, though evanescent characters scarcely describable in words. Hence the great value of photographs, drawings and water colours as an aid to determination.

As has already been mentioned, the mycological flora of Canada is comparatively little known, and as new species are continually being discovered in the United States and Europe where the greatest amount of work has been done, we may look forward to a rich harvest for future Canadian mycologists.

Much is being done in the United States to popularize this subject by the formation of mycological clubs, some of which are specially devoted to the discovery and testing of the numerous and valuable edible species, and the publication of bulletins. Among popular books on the subject may be mentioned Atkinson's "Mushrooms, Edible, Poisonous. etc.", published by Andrus & Church, Ithaca, N. Y., at $3.00, and Marshall's "Mushroom Book" obtainable from Wm. Briggs, Toronto, for $3.00. These are splendidly illustrated with photographs, and will serve as the best basis for the beginner. Numerous other works, some of them in several volumes, are available for students wishing to pursue the subject in greater detail. Among these authors may be mentioned, McIlvaine (one large volume), at $5.00, Massee (four volumes), Stevenson (two volumes), and Saccardo (fifteen volumes).