
Marx
Machiavelli
Chesterton
Emerson
Joyce
Abbott
Hardy
Montaigne
Cooper
Austen
Defoe
Melville
Haggard
Hugo
Carroll
Christie
Eliot
Grimmer
Stoker
Molière
Wilde
Maupassant
Byron
Einstein
Fitzgerald
Engels
Schiller
Garnett
Hawthorne
Smith
Kafka
Goethe
Dostoyevsky
Cotton
Hall
Baum
Kipling
Doyle
Willis
Henry
Leslie
Dumas
Nietzsche
Flaubert
Turgenev
Balzac
Stockton
Vatsyayana
Crane
Burroughs
Verne
Curtis
Tocqueville
Whitman
Gogol
Vinci
Homer
Widger
Tolstoy
Busch
Darwin
Thoreau
Potter
Freud
Zola
Twain
Scott
Lawrence
Plato
Kant
Jowett
Stevenson
Dickens
Harte
Andersen
Burton
Hesse
London
Descartes
Cervantes
Poe
Aristotle
Wells
Voltaire
Hale
James
Hastings
Cooke
Bunner
Shakespeare
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Richter
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Fungi: Their Nature and Uses

M. C. (Mordecai Cubitt) Cooke

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iii

THE INTERNATIONAL SCIENTIFIC SERIES.

FUNGI:

THEIR

NATURE AND USES.

BY
M. C. COOKE, M.A., LL.D.

EDITED BY
The Rev. M. J. BERKELEY, M.A., F.L.S.

NEW YORK:
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1875.

v

PREFACE BY THE EDITOR.

As my name appears on the title-page of this volume, it is necessary that I should exactly state what part I had in its preparation. I had no doubt originally engaged to undertake the work myself; but finding, from multiplicity of engagements and my uncertain health, that I could not accomplish it satisfactorily, I thought the best course I could take was to recommend Mr. Cooke to the publishers; a gentleman well known, not only in this country, but in the United States. The whole of the work has therefore been prepared by himself, the manuscript and proof sheets being submitted to me from time to time, in which I merely suggested such additions as seemed needful, subjoining occasionally a few notes. As the work is intended for students, the author has had no hesitation in vi repeating what has been stated in former chapters where it has been thought to prove useful. I have no doubt that the same high character will justly apply to this as to Mr. Cooke's former publications, and especially to his "Handbook of British Fungi."

M. J. BERKELEY.

Sibbertoft,

November 23, 1874.

vii

FUNGI

THEIR NATURE, USES, INFLUENCES, ETC.

I.

NATURE OF FUNGI.

The most casual observer of Nature recognizes in almost every instance that comes under his notice in every-day life, without the aid of logical definition, the broad distinctions between an animal, a plant, and a stone. To him, the old definition that an animal is possessed of life and locomotion, a plant of life without locomotion, and a mineral deficient in both, seems to be sufficient, until some day he travels beyond the circuit of diurnal routine, and encounters a sponge or a zoophyte, which possesses only one of his supposed attributes of animal life, but which he is assured is nevertheless a member of the animal kingdom. Such an encounter usually perplexes the neophyte at first, but rather than confess his generalizations to have been too gross, he will tenaciously contend that the sponge must be a plant, until the evidence produced is so strong that he is compelled to desert his position, and seek refuge in the declaration that one kingdom runs into the other so imperceptibly that no line of demarcation can be drawn between them. Between these two extremes of broad distinction, and no distinction, lies the ground occupied by the scientific student, who, whilst admitting that logical definition fails in assigning briefly and tersely the bounds of the three kingdoms, contends [Pg 2] that such limits exist so positively, that the universal scientific mind accepts the recognized limit without controversy or contradiction.

In like manner, if one kingdom be made the subject of inquiry, the same difficulties will arise. A flowering plant, as represented by a rose or a lily, will be recognized as distinct from a fern, a seaweed, or a fungus. Yet there are some flowering plants which, at first

sight, and without examination, simulate cryptogams, as, for example, many *Balanophoræ*, which the unscientific would at once class with fungi. It is nevertheless true that even the incipient botanist will accurately separate the phanerogams from the cryptogams, and by means of a little more, but still elementary knowledge, distribute the latter amongst ferns, mosses, fungi, lichens, and algæ, with comparatively few exceptions. It is true that between fungi and lichens there exists so close an affinity that difficulties arise, and doubts, and disputations, regarding certain small groups or a few species; but these are the exception, and not the rule. Botanists generally are agreed in recognizing the five principal groups of Cryptogamia, as natural and distinct. In proportion as we advance from comparison of members of the three kingdoms, through that of the primary groups in one kingdom, to a comparison of tribes, alliances, and orders, we shall require closer observation, and more and more education of the eye to see, and the mind to appreciate, relationships and distinctions.

We have already assumed that fungi are duly and universally admitted, as plants, into the vegetable kingdom. But of this fact some have even ventured to doubt. This doubt, however, has been confined to one order of fungi, except, perhaps, amongst the most illiterate, although now the animal nature of the *Myxogastres* has scarcely a serious advocate left. In this order the early condition of the plant is pulpy and gelatinous, and consists of a substance more allied to sarcode than cellulose. De Bary insinuated affinities with *Amœba*, [A] whilst Tulasne [Pg 3] affirmed that the outer coat in some of these productions contained so much carbonate of lime that strong effervescence took place on the application of sulphuric acid. Dr. Henry Carter is well known as an old and experienced worker amongst amœboid forms of animal life, and, when in Bombay, he devoted himself to the examination of the *Myxogastres* in their early stage, and the result of his examinations has been a firm conviction that there is no relationship whatever between the *Myxogastres* and the lower forms of animal life. De Bary has himself very much modified, if not wholly abandoned, the views once propounded by him on this subject. When mature, and the dusty spores, mixed with threads, sometimes spiral, are produced, the *Myxogastres* are so evidently close allies of the *Lycoperdons*, or Puffballs, as to leave no

doubt of their affinities. It is scarcely necessary to remark that the presence of zoospores is no proof of animal nature, for not only do they occur in the white rust (*Cystopus*), and in such moulds as *Peronospora*, [B] but are common in algæ, the vegetable nature of which has never been disputed.

There is another equally important, but more complicated subject to which we must allude in this connection. This is the probability of minute fungi being developed without the intervention of germs, from certain solutions. The observations of M. Trécul, in a paper laid before the French Academy, have thus been summarized:—1. Yeast cells may be formed in the must of beer without spores being previously sown. 2. Cells of the same form as those of yeast, but with different contents, arise spontaneously in simple solution of sugar, or to which a little tartrate of ammonia has been added, and these cells are capable of producing fermentation in certain liquids under favourable conditions. 3. The cells thus formed produce *Penicillium* like the cells of yeast. 4. On the other hand, the spores of *Penicillium* are capable of being transformed into yeast. [C] The interpretation of this is, that the mould *Penicillium* may be [Pg 4] produced from a sugar solution by "spontaneous generation," and without spore or germ of any kind. The theory is, that a molecular mass which is developed in certain solutions or infusions, may, under the influence of different circumstances, produce either animalcules or fungi. "In all these cases, no kind of animalcule or fungus is ever seen to originate from preexisting cells or larger bodies, but always from molecules." [D] The molecules are said to form small masses, which soon melt together to constitute a globular body, from which a process juts out on one side. These are the so-called *Torulæ*, [E] which give off buds which are soon transformed into jointed tubes of various diameters, terminating in rows of sporules, *Penicillium*, or capsules containing numerous globular seeds, *Aspergillus* (*sic*).

This is but another mode of stating the same thing as above referred to by M. Trécul, that certain cells, resembling yeast cells (*Torula*), are developed spontaneously, and that these ultimately pass through the form of mould called *Penicillium* to the more complex *Mucor* (which the writer evidently has confounded with *Aspergillus*, unless he alludes to the ascigerous form of *Aspergillus*, long

known as *Eurotium*). From what is now known of the polymorphism of fungi, there would be little difficulty in believing that cells resembling yeast cells would develop into *Penicillium*, as they do in *fact* in what is called the "vinegar plant," and that the capsuliferous, or higher condition of this mould may be a *Mucor*, in which the sporules are produced in capsules. The difficulty arises earlier, in the supposed spontaneous origination of yeast cells from molecules, which result from the peculiar conditions of light, temperature, &c., in which certain solutions are placed. It would be impossible to review all the arguments, or tabulate all the experiments, which have been employed for and against this theory. It could not be passed over in silence, since it has been one of the stirring questions of the day. The great problem how to exclude all germs [Pg 5] from the solutions experimented upon, and to keep them excluded, lies at the foundation of the theory. It must ever, as we think, be matter of doubt that all germs were not excluded or destroyed, rather than one of belief that forms known to be developed day by day from germs should under other conditions originate spontaneously.

Fungi are veritably and unmistakably plants, of a low organization, it is true, but still plants, developed from germs, somewhat analogous, but not wholly homologous, to the seeds of higher orders. The process of fertilization is still obscure, but facts are slowly and gradually accumulating, so that we may hope at some not very distant period to comprehend what as yet are little removed from hypotheses. Admitting that fungi are independent plants, much more complex in their relations and development than was formerly supposed, it will be expected that certain forms should be comparatively permanent, that is, that they should constitute good species. Here, also, efforts have been made to develop a theory that there are no legitimate species amongst fungi, accepting the terms as hitherto applied to flowering plants. In this, as in allied instances, too hasty generalizations have been based on a few isolated facts, without due comprehension of the true interpretation of such facts and phenomena. Polymorphism will hereafter receive special illustration, but meantime it may be well to state that, because some forms of fungi which have been described, and which have borne distinct names as autonomous species, are now proved to be only stages or conditions of other species, there is no reason for conclud-

ing that no forms are autonomous, or that fungi which appear and are developed in successive stages are not, in their entirety, good species. Instead, therefore, of insinuating that there are no good species, modern investigation tends rather to the establishment of good species, and the elimination of those that are spurious. It is chiefly amongst the microscopic species that polymorphism has been determined. In the larger and fleshy fungi nothing has been discovered which can shake our faith in the species described half a century, or more, ago. In the Agarics, for instance, the forms seem to be as permanent and [Pg 6] as distinct as in the flowering plants. In fact, there is still no reason to dissent, except to a very limited extent, from what was written before polymorphism was accredited, that, "with a few exceptions only, it may without doubt be asserted that more certain species do not exist in any part of the organized world than amongst fungi. The same species constantly recur in the same places, and if kinds not hitherto detected present themselves, they are either such as are well known in other districts, or species which have been overlooked, and which are found on better experience to be widely diffused. There is nothing like chance about their characters or growth." [F]

The parasitism of numerous minute species on living and growing plants has its parallel even amongst phanerogams in the mistletoe and broom-rape and similar species. Amongst fungi a large number are thus parasitic, distorting, and in many cases ultimately destroying, their host, burrowing within the tissues, and causing rust and smut in corn and grasses, or even more destructive and injurious in such moulds as those of the potato disease and its allies. A still larger number of fungi are developed from decayed or decaying vegetable matter. These are found in winter on dead leaves, twigs, branches, rotten wood, the remains of herbaceous plants, and soil largely charged with disintegrated vegetables. As soon as a plant begins to decay it becomes the source of a new vegetation, which hastens its destruction, and a new cycle of life commences. In these instances, whether parasitic on living plants or developed on dead ones, the source is still vegetable. But this is not always the case, so that it cannot be predicated that fungi are wholly epiphytal. Some species are always found on animal matter, leather, horn, bone, &c., and same affect such unpromising substances as miner-

als, from which it would be supposed that no nourishment could be obtained, not only hard gravel stones, fragments of rock, but also metals, such as iron and lead, of which more may be said when we come to treat of the habitats of fungi. Although in general terms fungi may be described as "hysterophytal or epiphytal mycetals deriving [Pg 7] nourishment by means of a mycelium from the matrix," [G] there are exceptions to this rule with which the majority accord.

Of the fungi found on animal substances, none are more extraordinary than those species which attack insects. The white mould which in autumn proves so destructive to the common house-fly may for the present be omitted, as it is probably a condition of one of the *Saprolegniei*, which some authors include with fungi, and others with algæ. Wasps, spiders, moths, and butterflies become enveloped in a kind of mould named *Isaria*, which constitutes the conidia of *Torrubia*, a genus of club-shaped *Sphæriæ* afterwards developed. Some species of *Isaria* and *Torrubia* also affect the larvæ and pupæ of moths and butterflies, converting the whole interior into a mass of mycelium, and fructifying in a clavate head. It has been subject for discussion whether in such instances the fungus commenced its development during the life of the insect, and thus hastened its death, or whether it resulted after death, and was subsequent to the commencement of decay. [H] The position in which certain large moths are found standing on leaves when infested with *Isaria* resembles so closely that of the house-fly when succumbing to *Sporendonema Muscæ*, would lead to the conclusion that certainly in some cases the insect was attacked by the fungus whilst still living; whilst in the case of buried caterpillars, such as the New Zealand or British *Hepialus*, it is difficult to decide. Whether in life or death in these instances, it is clear that the silk-worm disease *Muscardine* attacks the living insect, and causes death. In the case of the *Guêpes végétantes*, the wasp is said to fly about with the fungus partially developed.

In all fungi we may recognize a vegetative and a reproductive system: sometimes the first only becomes developed, and then the fungus is imperfect, and sometimes the latter is far more prominent than the former. There is usually an agglomeration of delicate threads, either jointed or not, which are somewhat analogous to the

roots of higher plants. These delicate threads [Pg 8] permeate the tissues of plants attacked by parasitic fungi, or they run over dead leaves forming whitened patches, formerly bearing the name of *Himantia*, but really the mycelium of some species of *Marasmius*. If checked or disturbed, the process stops here, and only a mycelium of interwoven threads is produced. In this condition the mycelium of one species so much resembles that of another, that no accurate determination can be made. If the process goes on, this mycelium gives rise to the stem and cap of an agaricoid fungus, completing the vegetative system. This in turn gives origin to a spore-bearing surface, and ultimately the fruit is formed, and then the fungus is complete; no fungus can be regarded as perfect or complete without its reproductive system being developed. In some this is very simple, in others it is as complex. In many of the moulds we have miniature representatives of higher plants in the mycelium or roots, stem, branches, and at length capsules bearing sporidia, which correspond to seeds. It is true that leaves are absent, but these are sometimes compensated by lateral processes or abortive branchlets. A tuft of mould is in miniature a forest of trees. Although such a definition may be deemed more poetic than accurate, more figurative than literal, yet few could believe in the marvellous beauty of a tuft of mould if they never saw it as exhibited under the microscope. In such a condition no doubt could be entertained of its vegetable character. But there is a lower phase in which these plants are sometimes encountered; they may consist only of single cells, or strings of cells, or threads of simple structure floating in fluids. In such conditions only the vegetative system is probably developed, and that imperfectly, yet some have ventured to give names to isolated cells, or strings of cells, or threads of mycelium, which really in themselves possess none of the elements of correct classification—the vegetative system, even, being imperfect, and consequently the reproductive is absent. As already observed, no fungus is perfect without fruit of some kind, and the peculiarities of structure and development of fruit form one of the most important elements in classification. To attempt, therefore, to give names to such imperfect fragments of undeveloped plants is almost as absurd [Pg 9] as to name a flowering plant from a stray fragment of a root-fibril accidentally cast out of the ground—nay, even worse, for identification would probably be easier. It is well to protest at all times

against attempts to push science to the verge of absurdity; and such must be the verdict upon endeavours to determine positively such incomplete organisms as floating cells, or hyaline threads which may belong to any one of fifty species of moulds, or after all to an alga. This leads us to remark, in passing, that there are forms and conditions under which fungi may be found when, fructification being absent—that is, the vegetative system alone developed—they approximate so closely to algæ that it is almost impossible to say to which group the organisms belong.

Finally, it is a great characteristic of fungi in general that they are very rapid in growth, and rapid in decay. In a night a puffball will grow prodigiously, and in the same short period a mass of paste may be covered with mould. In a few hours a gelatinous mass of *Reticularia* will pass into a bladder of dust, or a *Coprinus* will be dripping into decay. Remembering this, mycophagists will take note that a fleshy fungus which may be good eating at noon may undergo such changes in a few hours as to be anything but good eating at night. Many instances have been recorded of the rapidity of growth in fungi; it may also be accepted as an axiom that they are, in many instances, equally as rapid in decay.

The affinity between lichens and fungi has long been recognized to its full and legitimate extent by lichenologists and mycologists. [I] In the "Introduction to Cryptogamic Botany," it [Pg 10] was proposed to unite them in one alliance, under the name of *Mycetales*, in the same manner as the late Dr. Lindley had united allied orders under alliances in his "Vegetable Kingdom;" but, beyond this, there was no predisposition towards the theory since propounded, and which, like all new theories, has collected a small but zealous circle of adherents. It will be necessary briefly to summarize this theory and the arguments by which it is supported and opposed, inasmuch as it is intimately connected with our subject.

As recently as 1868, Professor Schwendener first propounded his views, [J] and then briefly and vaguely, that all and every individual lichen was but an algal, which had collected about it a parasitic fungal growth, and that those peculiar bodies which, under the name of *gonidia*, were considered as special organs of lichens, were only imprisoned algæ. In language which the Rev. J. M. Crombie

[K] describes as "pictorial," this author gave the general conclusion at which he had arrived, as follows:—"As the result of my researches, all these growths are not simple plants, not individuals in the usual sense of the term; they are rather colonies, which consist of hundreds and thousands of individuals, of which, however, only one acts as master, while the others, in perpetual captivity, provide nourishment for themselves and their master. This master is a fungus of the order *Ascomycetes*, a parasite which is accustomed to live upon the work of others; its slaves are green algæ, which it has sought out, or indeed caught hold of, and forced into its service. It surrounds [Pg 11] them, as a spider does its prey, with a fibrous net of narrow meshes, which is gradually converted into an impenetrable covering. While, however, the spider sucks its prey and leaves it lying dead, the fungus incites the algæ taken in its net to more rapid activity; nay, to more vigorous increase." This hypothesis, ushered upon the world with all the prestige of the Professor's name, was not long in meeting with adherents, and the cardinal points insisted upon were—1st. That the generic relationship of the coloured "gonidia" to the colourless filaments which compose the lichen thallus, had only been assumed, and not proved; 2nd. That the membrane of the gonidia was chemically different from the membrane of the other tissues, inasmuch as the first had a reaction corresponding to that of algæ, whilst the second had that of fungi; 3rd. That the different forms and varieties of gonidia corresponded with parallel types of algæ; 4th. That as the germination of the spore had not been followed further than the development of a hypothallus, it might be accounted for by the absence of the essential algal on which the new organism should become parasitic; 5th. That there is a striking correspondence between the development of the fruit in lichens and in some of the sporidiiferous fungi (*Pyrenomycetes*).

These five points have been combated incessantly by lichenologists, who would really be supposed by ordinary minds to be the most practically acquainted with the structure and development of these plants, in opposition to the theorists. It is a fact which should have some weight, that no lichenologist of repute has as yet accepted the theory. In 1873 Dr. E. Bornet [L] came to the aid of Schwendener, and almost exhausted the subject, but failed to convince either the practised lichenologist or mycologist. The two great

points sought to be established are these, that what we call lichens are compound organisms, not simple, independent vegetable entities; and that this compound organism consists of unicellular algæ, with a fungus parasitic upon them. The coloured gonidia which are found in the [Pg 12] substance, or thallus of lichens, are the supposed algæ; and the cellular structure which surrounds, encloses, and imprisons the gonidia is the parasitic fungus, which is parasitic on something infinitely smaller than itself, and which it entirely and absolutely isolates from all external influences.

Dr. Bornet believed himself to have established that every gonidium of a lichen may be referred to a species of algæ, and that the connection between the hypha and gonidia is of such a nature as to exclude all possibility of the one organ being produced by the other. This he thinks is the only way in which it can be accounted for that the gonidia of diverse lichens should be almost identical.

Dr. Nylander, in referring to this hypothesis of an imprisoned algal, [M] writes: "The absurdity of such an hypothesis is evident from the very consideration that it cannot be the case that an organ (gonidia) should at the same time be a parasite on the body of which it exercises vital functions; for with equal propriety it might be contended that the liver or the spleen constitutes parasites of the mammiferæ. Parasite existence is autonomous, living upon a foreign body, of which nature prohibits it from being at the same time an organ. This is an elementary axiom of general physiology. But observation directly made teaches that the green matter originally arises within the primary chlorophyll- or phycochrom-bearing cellule, and consequently is not intruded from any external quarter, nor arises in any way from any parasitism of any kind. The cellule at first is observed to be empty, and then, by the aid of secretion, green matter is gradually produced in the cavity and assumes a definite form. It can, therefore, be very easily and evidently demonstrated that the origin of green matter in lichens is entirely the same as in other plants." On another occasion, and in another place, the same eminent lichenologist remarks, [N] as to the supposed algoid nature of gonidia—"that such an unnatural existence as they would thus pass, enclosed in a prison and [Pg 13] deprived of all autonomous liberty, is not at all consonant with the manner of existence of the other algæ, and that it has no parallel in nature, for nothing