# FUNGAL ANATOMY

The Hidden Processes of Spore Production and Mycelial Growth

This is the normal condition, to which there are some exceptions. In the Melanconiei, there is no true perithecium, but the spores are produced in like manner upon a kind of stroma or cushion formed from the mycelium, and, when mature, are expelled through a rupture of the cuticle beneath which they are generated, often issuing in long gelatinous tendrils. Here, again, the majority of what were formerly regarded as distinct species have been found, or suspected, to be forms of higher fungi. The Torulacei represent the superficial fungi of this family, and these consist of a more or less developed mycelium, which gives rise to fertile threads, which, by constriction and division, mature into moniliform chains of spores. The species mostly appear as blackish velvety patches or stains on the stems of herbaceous plants and on old weathered wood.

Much interest attaches to the other sub-family of Coniomycetes, in which the species are produced for the most part on living plants. So much has been discovered during recent years of the polymorphism which subsists amongst the species in this section, that any detailed classification can only be regarded as provisional. Hence we shall proceed here upon the supposition that we are dealing with autonomous species. In the first place, we must recognize a small section in which a kind of cellular peridium is present. This is the Æcidiacei, or order of "cluster cups." The majority of species are very beautiful objects under the microscope; the peridia are distinctly cellular, and white or pallid, produced beneath the cuticle, through which they burst, and, rupturing at the apex, in one genus in a stellate manner, so that the teeth, becoming reflexed, resemble delicate fringed cups, with the orange, golden, brown, or whitish spores or pseudospores nestling in the interior.

[J] These pseudospores are at first produced in chains, but ultimately separate. In many cases these cups are either accompanied or preceded by spermogonia. In two other orders there is no peridium. In the Cæomacei, the pseudospores are more or less globose or ovate, sometimes laterally compressed and simple; and in Pucciniæi, they are elongated, often subfusiform and septate. In both, the pseudospores are produced in tufts or clusters direct from the mycelium. The Cæomacei might again be subdivided into Ustilagines[K] and Uredines. [L] In the former, the pseudospores are mostly dingy brown or blackish, and in the latter more brightly coloured, often yellowish.

The Ustilagines include the smuts and bunt of corn-plants, the Uredines include the red rusts of wheat and grasses. In some of the species included in the latter, two forms of fruit are found. In Melampsora, the summer pseudospores are yellow, globose, and were formerly classed as a species of Lecythea, whilst the winter pseudospores are brownish, elongated, wedgeshaped by compression, and compact. The Pucciniæi [M] differ primarily in the septate pseudospores, which in one genus (Puccinia) are uniseptate; in Triphragmium, they are biseptate; in Phragmidium, multiseptate; and in Xenodochus, moniliform, breaking up into distinct articulations. It is probable that, in all of these, as is known to be the case in most, the septate pseudospores are preceded or accompanied by simple pseudospores, to which they are mysteriously related.

There is still another, somewhat singular, group usually associated with the Pucciniæi, in which the septate pseudospores are immersed in gelatin, so that in many features the species seem to approach the Tremellini. This group includes two or three genera, the type of which will be found in Podisoma. [N] These fungi are parasitic on living junipers in Britain and North America, appearing year after year upon the same gouty swellings of the branches, in clavate or horn-shaped gelatinous processes of a yellowish or orange colour. Anomalous as it may at first sight appear to include these tremelloid forms with the dust-like fungi, their relations will on closer examination be more fully appreciated, when the form of pseudospores, mode of germination, and other features are taken into consideration, especially when compared with Podisoma Ellisii, already alluded to.

This family is technically characterized as,— Distinct hymenium none. Pseudospores either solitary or concatenate, produced on the tips of generally short threads, which are either naked or contained in a perithecium, rarely compacted into a gelatinous mass, at length producing minute spores = CONIOMYCETES. The last family of the sporifera is Hyphomycetes, in which the threads are conspicuously developed. These are what are more commonly called “moulds,” including some of the most elegant and delicate of microscopic forms. It is true of many of these, as well as of the Coniomycetes, that they are only conidial forms of higher fungi; but there will remain a very large number of species which, as far as present knowledge extends, must be accepted as autonomous. In this family, we may again recognize three subdivisions, in one of which the threads are more or less compacted into a common stem, in another the threads are free, and in the third the threads can scarcely be distinguished from the mycelium.

It is this latter group which unites the Hyphomycetes with the Coniomycetes, the affinities being increased by the great profusion with which the spores are developed. The first group, in which the fertile threads are united so as to form a compound stem, consists of two small orders, the Isariacei and the Stilbacei, in the former of which the spores are dry, and in the latter somewhat gelatinous. Many of the species closely imitate forms met with in the Hymenomycetes, such as Clavaria; and, in the genus Isaria, it is almost beyond doubt that the species found on dead insects, moths, spiders, flies, ants, &c., are merely the conidiophores of species of Torrubia.

[O] The second group is by far the largest, most typical, and attractive in this family. It contains the black moulds and white moulds, technically known as the Dematiei and the Mucedines. In the first, the threads are more or less corticated, that is, the stem has a distinct investing membrane, which peels off like a bark; and the threads, often also the spores, are dark-coloured, as if charred or scorched. In many cases, the spores are highly developed, large, multiseptate, and nucleate, and seldom are spores and threads colourless or of bright tints. In the Mucedines, on the contrary, the threads are never coated, seldom dingy, mostly white or of pure colours, and the spores have less a tendency to extra development or multiplex septation. In some genera, as in Peronospora for instance, [P] a secondary fruit is produced in the form of resting spores from the mycelium; and these generate zoospores as well as the primary spores, similar to those common in Algæ.

This latter genus is very destructive to growing plants, one species being the chief agent in the potato disease, and another no less destructive to crops of onions. The vine disease is produced by a species of Oidium, which is also classed with Mucedines, but which is really the conidiiferous form of Erysiphe. In other genera, the majority of species are developed on decaying plants, so that, with the exception of the two genera mentioned, the Hyphomycetes exert a much less baneful influence on vegetation than the Coniomycetes. The last section, including the Sepedoniei, has been already cited as remarkable for the suppression of the threads, which are scarcely to be distinguished from the mycelium; the spores are profuse, nestling on the floccose mycelium; whilst in the Trichodermacei, the spores are invested by the threads, as if enclosed in a sort of false peridium.

A summary of the characters of the family may therefore be thus briefly expressed:— Filamentous; fertile threads naked, for the most part free or loosely compacted, simple or branched, bearing the spores at their apices, rarely more closely packed, so as to form a distinct common stem = HYPHOMYCETES. Having thus disposed of the Sporifera, we must advert to the two families of Sporidiifera. As more closely related to the Hyphomycetes, the first of these to be noticed is the Physomycetes, in which there is no proper hymenium, and the threads proceeding from the mycelium bear vesicles containing an indefinite number of sporidia. The fertile threads are either free or only slightly felted. In the order Antennariei, the threads are black and moniliform, more or less felted, bearing irregular sporangia.

A common fungus named Zasmidium cellare, found in cellars, and incrusting old wine bottles, as with a blackened felt, belongs to this order. The larger and more highly-developed order, Mucorini, differs in the threads, which are simple or branched, being free, erect, and bearing the sporangia at the tips of the thread, or branches. Some of the species bear great external resemblance to Mucedines until the fruit is examined, when the fructifying heads, commonly globose or ovate, are found to be delicate transparent vesicles, enclosing a large number of minute sporidia; when mature, the sporangia burst and the sporidia are set free. In some species, it has long been known that a sort of conjugation takes place between opposite threads, which results in the formation of a sporangium.

[Q] None of these species are destructive to vegetation, appearing only upon decaying, and not upon living, plants. A state approaching putrescence seems to be essential to their vigorous development. The following characters may be compared with those of the family preceding it:— Filamentous, threads free or only slightly felted, bearing vesicles, which contain indefinite sporidia = PHYSOMYCETES. In the last family, the Ascomycetes, we shall meet with a very great variety of forms, all agreeing in producing sporidia contained in certain cells called asci, which are produced from the hymenium. In some of these, the asci are evanescent, but in the greater number are permanent. In Onygenei, the receptacle is either club-shaped or somewhat globose, and the peridium is filled with branched threads, which produce asci of a very evanescent character, leaving the pulverulent sporidia to fill the central cavity. The species are all small, and singular for their habit of affecting animal substances, otherwise they are of little importance.

The Perisporiacei, on the other hand, are very destructive of vegetation, being produced, in the majority of cases, on the green parts of growing plants. To this order the hop mildew, rose mildew, and pea mildew belong. The mycelium is often very much developed, and in the case of the maple, pea, hop, and some others, it covers the parts attacked with a thick white coating, so that from a distance the leaves appear to have been whitewashed. Seated on the mycelium, at the first as little orange points, are the perithecia, which enlarge and become nearly black. In some species, very elegant whitish appendages radiate from the sides of the perithecia, the variations in which aid in the discrimination of species. The perithecia contain pear-shaped asci, which spring from the base and enclose a definite number of sporidia. [R] The asci themselves are soon dissolved.

Simultaneously with the development of sporidia, other reproductive bodies are produced direct from the mycelium, and in some species as many as five different kinds of reproductive bodies have been traced. The features to be remembered in Perisporiacei, as forming the basis of their classification, are, that the asci are saccate, springing from the base of the perithecia, and are soon absorbed. Also that the perithecia themselves are not perforated at the apex. The four remaining orders, though large, can be easily characterized. In Tuberacei, all the species are subterranean, and the hymenium is mostly sinuated. In Elvellacei, the substance is more or less fleshy, and the hymenium is exposed. In Phacidiacei, the substance is hard or leathery, and the hymenium is soon exposed.

And in Sphæriacei, although the substance is variable, the hymenium is never exposed, being enclosed in perithecia with a distinct opening at the apex, through which the mature spores escape. Each of these four orders must be examined more in detail. The Tuberacei, or subterranean Ascomycetes, are analogous to the Hypogæi of the Gasteromycetes. The truffle is a familiar and highly prized example. There is a kind of outer peridium, and the interior consists of a fleshy hymenium, more or less convoluted, sometimes sinuous and confluent, so as to leave only minute elongated and irregular cavities, and sometimes none at all, the two opposing faces of the hymenium meeting and coalescing. [S] Certain privileged cells of the hymenium swell, and ultimately become asci, enclosing a definite number of sporidia. The sporidia in many cases are large, reticulated, echinulate or verrucose, and mostly somewhat globose.

In the genus Elaphomyces, the asci are more than commonly diffluent. The Elvellacei are fleshy in substance, or somewhat waxy, sometimes tremelloid. There is no peridium, but the hymenium is always exposed. There is a great variety of forms, some being pileate, and others cup-shaped, as there is also a great variation in size, from the minute Peziza, small as a grain of sand, to the large Helvella gigas, which equals in dimensions the head of a child. In the pileate forms, the stroma is fleshy and highly developed; in the cup-shaped, it is reduced to the external cells of the cup which enclose the hymenium. The hymenium itself consists of elongated fertile cells, or asci, mixed with linear thread-like barren cells, called paraphyses, which are regarded by some authors as barren asci.

These are placed side by side in juxtaposition with the apex outwards. Each ascus contains a definite number of sporidia, which are sometimes coloured. When mature, the asci explode above, and the sporidia may be seen escaping like a miniature cloud of smoke in the light of the mid-day sun. The disc or surface of the hymenium is often brightly coloured in the genus Peziza; tints of orange, red, and brown having the predominance. In Phacidiacei, the substance is hard and leathery, intermediate between the fleshy Elvellacei and the more horny of the Sphæriacei. The perithecia are either orbicular or elongated, and the hymenium soon becomes exposed. In some instances, there is a close affinity with the Elvellacei, the exposed hymenium being similar in structure, but in all the disc is at first closed. In orbicular forms, the fissure takes place in a stellate manner from the centre, and the teeth are reflexed.

In the Hysteriacei, where the perithecia are elongated, the fissure takes place throughout their length. As a rule, the sporidia are more elongated, more commonly septate, and more usually coloured, than in Elvellacei. Only a few solitary instances occur of individual species that are parasitic on living plants. In the Sphæriacei, the substance of the stroma (when present) and of the perithecia is variable, being between fleshy and waxy in Nectriei, and tough, horny, sometimes brittle, in Hypoxylon. A perithecium, or cell excavated in the stroma which fulfils the functions of a perithecium, is always present. The hymenium lines the inner walls of the perithecium, and forms a gelatinous nucleus, consisting of asci and paraphyses.

When fully mature, the asci are ruptured and the sporidia escape by a pore which occupies the apex of the perithecium. Sometimes the perithecia are solitary or scattered, and sometimes gregarious, whilst in other instances they are closely aggregated and immersed in a stroma of variable size and form. Conidia, spermatia, pycnidia, &c., have been traced to and associated with some species, but the history of others is still obscure. Many of the coniomycetous forms grouped under the Sphæronemei are probably conditions of the Sphæriacei, as are also the Melanconiei, and some of the Hyphomycetes. A very common fungus, for instance, which is abundant on sticks and twigs, forming rosy or reddish pustules the size of a millet seed, formerly named Tubercularia vulgaris, is known to be the conidia-bearing stroma of the sphæriaceous fungus, Nectria cinnabarina; [T] and so with many others.

The following are the technical characters of the family:— Fruit consisting of sporidia, mostly definite, contained in asci, springing from a naked or enclosed stratum of fructifying cells and forming a hymenium or nucleus = ASCOMYCETES. If the characters of the different families are borne in mind, there will be but little difficulty in assigning any fungus to the order to which it belongs by means of the foregoing remarks. For more minute information, and for analytical tables of the families, orders, and genera, we must refer the student to some special systematic work, which will present fewer difficulties, if he keeps in mind the distinctive features of the families. [U] To assist in this we have given on the following page an analytical arrangement of the families and orders, according to the system recognized and adopted in the present volume.

It is, in all essential particulars, the method adopted in our “Handbook,” based on that of Berkeley’s “Introduction” and “Outlines.” The rigid utilitarian will hardly be satisfied with the short catalogue which can be furnished of the uses of fungi. Excepting those which are employed more or less for human food, very few are of any practical value in arts or medicine. It is true that imperfect conditions of fungi exert a very important influence on fermentation, and thus become useful; but, unfortunately, fungi have the reputation of being more destructive and offensive than valuable or useful. Notwithstanding that a large number of species have from time to time been enumerated as edible, yet those commonly employed and recognized are very few in number, prejudice in many cases, and fear in others, militating strongly against additions to the number.

In Great Britain this is especially the case, and however advisable it may be to exercise great care and caution in experimenting on untried or doubtful species, it can only be regarded as prejudice which prevents good, in fact, excellent, esculent species being more extensively used, instead of allowing them to rot by thousands on the spots where they have grown. Poisonous species are also plentiful, and no golden rule can be established by means of which any one may detect at a glance good from bad, without that kind of knowledge which is applied to the discrimination of species. Yet, after all, the characters of half a dozen good esculent fungi are acquired as easily as the distinctions between half a dozen birds such as any ploughboy can discriminate.

The common mushroom (Agaricus campestris) is the best known esculent, whether in its uncultivated or in a cultivated state. In Britain many thousands of people, notably the lower classes, will not recognize any other as fit for food, whilst in Italy the same classes have a strong prejudice against this very species. [A] In Vienna, we found by personal experience that, although many others are eaten, it is this which has the most universal preference, yet it appears but sparingly in the markets as compared with others. In Hungary it does not enjoy by any means so good a reputation. In France and in Germany it is a common article of consumption. The different varieties found, as the results of cultivation, present some variation in colour, scaliness of pileus, and other minor features, whilst remaining true to the constituent characters of the species.

Although it is not our intention to enumerate here the botanical distinctions of the species to which we may call attention, yet, as mistakes (sometimes fatal) are often being recorded, in which other fungi are confounded with this, we may be permitted a hint or two which should be remembered. The spores are purple, the gills are at first delicate pink, afterwards purple; there is a permanent ring or collar round the stem, and it must not be sought in woods. Many accidents might have been spared had these facts been remembered. The meadow mushroom (Agaricus arvensis) is common in meadows and lowland pastures, and is usually of a larger size than the preceding, with which it agrees in many particulars, and is sent in enormous quantities to Covent Garden, where it frequently predominates over Agaricus campestris.

Some persons prefer this, which has a stronger flavour, to the ordinary mushroom, and it is the species most commonly sold in the autumn in the streets of London and provincial towns. According to Persoon, it is preferred in France; and, in Hungary, it is considered as a special gift from St. George. It has acquired in England the name of horse mushroom, from the enormous size it sometimes attains. Withering mentions a specimen that weighed fourteen pounds. [B] One of the commonest (in our experience the most common) of all edible fungi in the public markets of Vienna is the Hallimasche (Agaricus melleus), which in England enjoys no good reputation for flavour or quality; indeed, calls it “nauseous and disagreeable,” and adds that “not to be poisonous is its only recommendation.”

In Vienna it is employed chiefly for making sauce; but we must confess that even in this way, and with a prejudice in favour of Viennese cookery, our experience of it was not satisfactory. It is at best a sorry substitute for the mushroom. In the summer and autumn this is a very common species in large tufts on old stumps. In similar localities, and also in tufts, but neither so large, nor so common, Agaricus fusipes is found. It is preferable to the foregoing as an esculent, and is easily recognized by the spindle-shaped stem. Agaricus rubescens, P., belongs to a very suspicious group of fungi, in which the cap or pileus is commonly studded or sprinkled with paler warts, the remains of an investing volva. To this group the poisonous but splendid fly-agaric (Agaricus muscarius) belongs.

Notwithstanding its bad company, this agaric has a good reputation, especially for making ketchup; and Cordier reports it as one of the most delicate mushrooms of the Lorraine. [C] Its name is derived from its tendency to become red when bruised. The white variety of an allied species (Agaricus vaginatus) has been commended, and Dr. Badham says that it will be found inferior to but few agarics in flavour. A scaly-capped fungus (Agaricus procerus), with a slender stem, called sometimes the parasol mushroom, from its habit, is an esteemed esculent. In Italy and France it is in high request, and is included in the majority of continental works on the edible fungi. [D] In Austria, Germany, and Spain, it has special “vulgar” names, and is eaten in all these countries. It is much more collected in England than formerly, but deserves to be still better known.

When once seen it can scarcely be confounded with any other British species, save one of its nearest allies, which partakes of its own good qualities (Agaricus rachodes), though not quite so good. Agaricus prunulus, Scop., and Agaricus orcella, Badh., if they be not forms of the same species (which contends that they are not [E]), have also a good reputation as esculents. They are both neat, white agarics, with a mealy odour, growing respectively in woods and open glades. Agaricus nebularis, Batsch, is a much larger species, found in woods, often in large gregarious patches amongst dead leaves, with a smoky mouse-coloured pileus, and profuse white spores. It is sometimes as much as five or six inches in diameter, with rather a faint odour and mild taste.

On the continent, as well as in Britain, this is included amongst edible fungi. Still larger and more imposing is the magnificent white species, Agaricus maximus, Fr., [F] which is figured by Sowerby, [G] under the name of Agaricus giganteus. It will attain a diameter of fourteen inches, with a stem, two inches thick, and rather a strong odour. A spring fungus, the true St. George's mushroom, Agaricus gambosus, Fr., makes its appearance in pastures, usually growing in rings, in May and June, and is welcome to mycophagists from its early growth, when esculent species are rare. It is highly esteemed in France and Italy, so that when dried it will realize as much as from twelve to fifteen shillings per pound. Guillarmod includes it amongst Swiss esculents.

[H] Professor Buckman says that it is one of the earliest and best of English mushrooms, and others have endorsed his opinions, and in writing of it observes, that small baskets of them, when they first appear in the spring in Italy, are sent as "presents to lawyers and fees to medical men." The closely allied species, Agaricus albellus, [I] D.C., has also the reputation of being edible, but it is so rare in England that this quality cannot be put to the test. The curious short-stemmed Agaricus brevipes, Bull, [J] has a similar reputation. Two singularly fragrant species are also included amongst the esculent. These are Agaricus fragrans, Sow., and Agaricus odorus, Bull. Both have a sweet anise-like odour, which is persistent for a long time. The former is pale tawnycoloured, nearly white, the latter of a dirty pale green. Both are white-spored, and although somewhat local, sufficient specimens of Ag. odorus may be collected in the autumn for domestic use.