the comet's orbit to an earlier date in November, is now fully corroborated by the conspicuous appearance of the same meteor-shower which has recently appeared. Had it, indeed, been possible to estimate exactly the motion of the comet's nodes during the interval since their previous return, the date on which the great meteor-shower observed on Wednesday last occurred, might have been accurately foretold. The Luminous Meteor Committee of the British Association requested observers to co-operate for its observation on the evenings of the 28th to 30th of last month, and to keep an occasional watch for its return from the 25th until the last day of November. The observations received from some of these observers are ample proofs of their success; and among the copious descriptions of the shower which have appeared by many expert astronomers throughout the kingdom, little can be desired to increase the extent or accuracy of the information which has been obtained. Should it, however, be observed that a star shower like that seen by Heis, and earlier observed on the 6th and 7th of December, is again visible on about the 5th of December in this year, its connection with the companion comet I., 1818, of Biela's comet, may become a matter of interesting deductions from such observations, and of further satisfactory investigations.

A. S. HERSCHEL

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*FERMENTATION AND PUTREFACTION**

II.

IN the interesting inquiry into the life-history of mildews, a well-known one, abundant wherever organic matter, in a somewhat inert state, is exposed to damp, *Aspergillus glaucus*, may be taken as well as the *Mucor mucedo*. This consists in the first place of a mass of mycelium filaments, which are formed of delicate cells in chains, that is to say, the fibres are divided into series of true cells by diaphragms. The cells are full of protoplasm, at first showing a distinct nucleus, and afterwards a number of vacuoles containing water. The filaments grow at the ends, and new partitions there grow up—at first close together, and afterwards separating and becoming more distinct. Some of the filaments become spiral at the end and finally develop peculiar reproductive organs which will be noticed presently. *Aspergillus* frequently presents for long nothing but this spreading jointed mycelium, feeding upon the surface, and penetrating into the substance of organic matter, and rotting and burning it; producing water, carbon dioxide, sulphuretted hydrogen, various butyric compounds, and other products of decomposition, without developing any special organs of its own. In this state it is perfectly impossible to distinguish it from the mycelium of many other fungi. No doubt there are differences—there are marked differences from some mycelia, for instance those of the Mucors where the filaments are undivided—but most have divided filaments, and these organs are so small, so simple, and so variable, that it is next to impossible to appreciate the distinctive characters. Under favourable circumstances, in the light and air, *Aspergillus* rises into the form of a bluish mould. This under the microscope shows a multitude of one-celled upright stalks, which form a kind of fur on the surface which it has attacked. Each of these stalks, which may be called *conidia-stems*, is dilated at the upper end, and from this dilatation there project, bristling all over the knob, a number of conical protuberances called *sterigmata*. Each sterigma becomes pointed towards its free end, and at length produces at the point a small round cell filled with protoplasm, which remains attached to the sterigma by a fine pedicel. Behind this cell, between it and the end of the sterigma, another cell then forms, and then another, until little chains of cells stand out free from the ends of the sterigmata; and as all these are of the same age, they are symmetrical, and of the same length. The farthest from the sterigmata are, of course, the oldest, and some of these soon get dry and ripe; so that an impalpable dust of these propagating buds or *conidia* is perpetually coming off, wafted by the slightest breath, or even by the imperceptible convection-currents from which the air is never free, from the surface of a mould patch. The conidia are buds capable of germination, of producing plants which go through the same course as their parent, but they are not reproductive products. At the ends of the spiral curls of the mycelium filaments at certain seasons, and under favourable circumstances, large bodies are produced by a form of conjugation in which cells are multiplied till they form a mass of considerable size of a bright yellow colour, called a *utricle*. Some of the cells composing the utricle become dissolved, while the greater number are developed into oval sacs or *asci*, in each of which eight spores are produced. These utricles are the true sexual reproductive organs. We have thus two kinds of spores—conidia, which are non-sexual buds, and asci-spores, the product of a form of sexual union. *Aspergillus* often bears conidia without utricles, and this is always the case when the fungus is badly nourished. It never, apparently, bears utricles without conidia. The appearance of the two modes of reproduction is so different, that the name *Aspergillus* was, until lately, restricted to mycelium bearing the conidia form of multiplication, while the utricle-bearing filaments and utricles were placed in another genus, *Eurotium*.

When sown, say on a solution of sugar or on any other suitable soil, the behaviour of the two kinds of spores is exactly the same. The spores send out tubes, which take the character of mycelium; and whose filaments in either case subsequently bear conidia or utricles according to circumstances.

Botrytis cinerea, a fungus specially abundant on decaying vine-leaves, produces conidia in elegant panicles, and a utricle which assumes such large proportions, and such a definite form, that it has been placed in the great genus *Peziza*, under the name of *P. fuckeliana*.

Not to multiply examples too much, I will briefly refer to a form, the life history of which is not yet thoroughly known—the mould which so often occurs in sour milk, though it is by no means confined to that station—*Oidium lactis*. The mycelium of *Oidium* is extremely like that of *Aspergillus glaucus*, having filaments divided into distinct cells by marked septa. From the mycelium long single shoots rise in the air, and give off chains of conidia; each shoot representing one of the sterigmata of *Aspergillus* with its progeny. *Oidium* attacks all kinds of fermentable substances, and consequently its conidia are frequently, almost constantly, met with in fœcal matter;

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* From the Opening Address for the Session 1872-73 to the Botanical Society of Edinburgh, delivered on Nov. 14, by Prof. Wyville Thomson, F.R.S., President of the Society. Concluded from p. 62.

and, like many other innocent fungi, it has had the credit of producing the Asiatic cholera, and rejoices, among other synonyms, in the name of *Cylindrotænium choleræ*.

In solutions containing sugar we often find a multitude of round or oval cells, precisely resembling the cells which I have already described in other fungi; a delicate membrane surrounding a mass of protoplasm, with one or two water vacuoles; each cell is about $\frac{1}{100}$ mm. in diameter; the cells are in twos or threes, or frequently run together in strings, like a breaking up chain of gemmules of a *Mucor*. These are the well-known *Saccharomyces cerevisiæ*, the yeast fungus. In multiplying, which they do with extraordinary rapidity, these yeast cells throw up irregularly from the surface one or more buds, much as other fungi produce conidia. These separate, and in turn multiply in the same way; but the last stage in the development of this fungus is one which brings it into the regular series of ascomycetous fungi, the formation of regular asci or utricles, which correspond exactly with the asci of *Aspergillus*. These contain four to eight spores, which, when placed under favourable circumstances, vegetate in the ordinary way. It is after the sprouting of fresh yeast has taken place for some time in a fermenting solution, and has become languid, that the formation of asci begins, and we can produce them artificially by taking yeast out of a solution of sugar, and placing it upon the surface of a fresh vegetable, such as a slice of carrot. From yeast we pass to a series of very nearly-allied forms, which, as we shall see hereafter, perform a somewhat different function, the difference altering their value prodigiously in human economy. In sour wine and beer, in the process of the manufacture of vinegar, and wherever we have what is called the acetous fermentation, minute bodies swarm in the solution which closely resemble yeast, differing chiefly in the smaller size of the cells. Sometimes these appear in pairs, sometimes single, and sometimes as little vibrating jointed rods. The best known, and perhaps the most mischievous, are the mould fungus of sour wine, *Mycoderma vini*, and the "mother of vinegar," *Mycoderma aceti*. These are called *Mycoderma* because the cells are entangled in a sort of slimy film.

From these we pass to another class of bodies scarcely distinguishable from them morphologically, but usually even still more minute, which are universally spread wherever putrefactive decomposition is going on, *Bacteria* and *Vibriones*. These and the lactic acid, and butyric acid yeast-fungi cannot, however, so far as we at present know, be ranged with the *Ascomyceti*, but must be placed in another group, for which the term *Schyzomyceti* has been proposed parallel with the Nostocs among Confervoids.

Having thus given a very brief sketch of the morphology of this singular group of beings, I should wish to make one or two general remarks. In the first place, with De Bary, I would exhort you to remember that these beings whose morphology we have been discussing, although they are very small, are nevertheless *plants*, each going through its own life-history, and presenting at different periods, and in connection with the performance of the different functions of its life, definite forms like every other plant. You know how to think about peas and beans, oats and rye-grass, and after sowing a crop of peas you never go and watch it, wondering whether it will come up peas or barley. You never watch the growth of a turnip, expecting to find it gradually turning into a carrot; and you never set aside a bowl of gruel and wait till acorns come in it, and wonder whether, if they do come, they will sprout into cabbages or hedgehogs; and yet there are slight difficulties in the study of the plants which we have been describing which have led men apparently otherwise well instructed to write reams of trash, gravely advocating absurdities of essentially the same order. These difficulties are in the first place that these plants are extremely minute, and their investigation requires great skill in manipulation, and great practice. Again, they are enormously abundant, and their multiplying germs of all kinds are so minute and all-pervading that it requires the utmost experimental dexterity to separate them, to sow them, and still more to exclude them. If we attempt to select and sow one species, ten to one the seed is mixed with the seeds of a multitude of weeds, and if during the process we allow the most indirect and instantaneous communication with the open air, instantly the enemy sows tares among our wheat, and one of these, probably more vigorous than the others, in the course of an hour has cut short its weak struggle for life. Then the form of these plants requires very careful study—some parts of them, such as the universally diffused mycelium, are undistinguishable in different species; and so are the gemmules, conidia, and spores examined singly. It is often only when the entire "fructification" is present that distinguishing characteristics exist which one can grasp. Then there is another difficulty—most of these plants present some form of the singular phenomenon of pleomorphy; perhaps not more so than other plants, but slight differences in form tell greatly in such simple and critical organisms. They present different forms at different periods of growth, and under slightly different circumstances. It is therefore not the appearance of the particular mould-fungus at any one time which we have to consider, but its life history. In this, however, as in all other such cases, we must apply the ordinary rules of experience and common sense. A plant of rhubarb, pink and clear, drawn up and forced in a can, is very unlike the same plant grown outside, with great green leaves and giving off a multitude of multiplying buds from its root crown; and without some little knowledge and experience it would be difficult to identify either of these with the plant in the autumn in its reproductive stage, shooting up its stately axis with its myriad of white feathery flowers. The difficulties in studying the small fungi are very great, but a few men, not perhaps very many, are capable of dealing with such difficulties, and by the application of the methods and reasoning of such men as De Bary, Pasteur, Lister, Burdon Sanderson, and Hartley, men trained in skilful investigation and accurate thought, the wild misconceptions which have lately gathered about the whole subject are fast passing away.

I will now turn for a few minutes from the morphological to the physiological part of the question, from the researches of M. De Bary to those of M. Pasteur.

These active little scavengers, the microscopic fungi, live upon and in, spread their mycelium over and through, and flourish on the surface of decaying vegetable and animal matter; but it is not the decay which produces the fungi, it is the fungi which produce the particular form of decay.

When a mildew is growing in the ordinary way in the free air on the surface of a liquid containing sugar, or on the surface of a plant, it absorbs oxygen from the air, and combines the oxygen thus absorbed with carbon, the product of the decomposition of the matter on which it is growing, so that by this ordinary process of burning, carbon dioxide and water are set free, while at the same time putrefaction is kept up in the substance attacked. If protein compounds be present, then ammonia, sulphuretted hydrogen, and other substances are likewise set at liberty, making the putrefaction more offensive. The fungus is, in this case, feeding upon the organic matter, and breathing the oxygen just like an animal. It cannot decompose carbonic acid if it be freely supplied with this gas. Without any other source of carbon, it does not increase. The relation of fungi to the other substances required for their growth is still uncertain. It has been supposed, and experiment seems to favour the opinion, that fungi can assimilate the nitrogen of ammonia and nitric acid, and even that they can absorb and assimilate the nitrogen of the air. I should think this very doubtful. It would seem most probable that in their relation to their surrounding sources of nourishment, their reactions are the same as those of animals and of the pale parts of the higher plants.

Pasteur has shown that the same plants which, when growing fully exposed to the air and liberally supplied with oxygen, produce putrefaction, will, when partially or wholly excluded from the air, and deprived of a full supply of oxygen, produce fermentation—that is to say, will induce and keep up a set of changes resulting in the production, not of carbonic acid and water, but of alcohol, or of acetic, butyric, or lactic acid.

The *rationale* of this process proposed for acceptance by Pasteur is singularly beautiful, and will, if correct, cause a great change in our ideas of the vital relations of these lower living forms. He believes that ferments are living beings with this special property—that they can perform all their vital functions without being in contact with free oxygen gas; that they can take the oxygen which is necessary for their respiration, and for other changes in the organic matter upon which they are feeding, from organic compounds containing oxygen, such as sugar; that they can decompose and burn these, and in doing so induce in a large quantity of fermentable material the conversion of sugar into alcohol. Pasteur cites the following experiment:—

If we half fill a flask with a fermentable liquid such as a solution of sugar, and having taken all care to exclude all other germs, sow on its surface some spores of *Mycoderma vini* or *Penicillium glaucum*, the fungus grows and flourishes on the surface, feeding on the organic matter in the solution, absorbing oxygen from the air, and throwing off carbon dioxide. In this case no alcohol is produced. If we now shake the flask, the film of fungus sinks through the liquid, and for a time there is no further change; but after resting a little, if the temperature be kept up, bubbles of carbon dioxide begin to rise from the fungus, which continues to grow, although more slowly. Fermentation sets in instead of putrefaction, and alcohol is produced in sensible quantities. The one great change which has been produced in the circumstances of the fungus is that it has now been almost wholly excluded from contact with free oxygen, while in its former condition it was bathed in it. Upon this change, according to Pasteur, depends its now acting as a ferment instead of inducing putrefaction.

A ferment, then, is a living body which is special in this respect; that it is capable of performing all the functions of its life apart from free oxygen; it can assimilate directly oxygenated matters such as sugar, and derive from them the requisite amount of heat, and it further can produce the decomposition of a much greater weight of fermentable matter than the weight of the ferment in action. Pasteur has found that ferments such as yeast lose their fermenting power— that is to say, the amount of organic matter decomposed diminishes and approaches the weight of the ferment employed—exactly in proportion to the amount of free oxygen supplied.

Pasteur has also shown, and this is one of the most curious results of his investigations, that the same fungus does not incite or maintain the alcholic, the acetic acid, the lactic acid, or the butyric acid fermentations; but that these changes are produced by different species, nearly allied but distinguishable from one another under the microscope; the specific differences between them extending to this strange difference in their powers of nutrition or respiration which induces different reactions in a fermentable fluid.

In the course of the foregoing remarks we have digressed widely from our text, the ripening and rotting "Duchesse d'Angoulême" pears; but, before concluding, let us for a moment recur to them, and see how far the facts and theories which I have brought before you are applicable to the considerations from which we started—their ripening and their decay. This ripe pear, during its early growth, was green. The cells in its outer layer contained chlorophyll, and contributed their quota to the shaking asunder of the elements of carbon dioxide and water under the influence of light—to the nutrition of the pear tree. Its inner pale cells grew, amply supplied with food from the elaborated sap, and with oxygen suspended in the percolating fluids and passing through the many ducts. Thus at that period growth was going on, and neither fermentation nor putrefaction. Sugar, starch, and various substances were then laid down in the cells, and when the pear had acquired its full growth, the connection with the tree was cut off, but the surface of the fruit remained still freely exposed o the air. A considerable quantity of sugar is now decomposed in the interior of the fruit, and the result is the production of a trace of alcohol and certain ethers—the development of the flavour of the pear; but shortly the outside softens by the ordinary production of water and carbon dioxide in contact with the oxygen of the air, the pear loses flavour again, and commences to decay. M. Bérard has shown that if a ripening fruit be placed in an atmosphere of carbon dioxide no such softening occurs. The changes are much less rapid, the inner cells of the pear act as a ferment, and while carbon dioxide is still given off it is now at the expense of the sugar, and a large quantity of alcohol is the result. M. Pasteur tried this experiment with four dozen "Monsieur" plums taken nearly ripe from the tree; twenty-four of these were placed in an atmosphere of carbon dioxide, and after several days, during which time they seemed quite firm and fresh, they gave to analysis 6·50 grammes of absolute alcohol, and a corresponding quantity of sugar was destroyed; the other twenty-four were left in contact with the air, and had became soft, watery, and sweet. It is the active vitality of a living plant, which consists of materials very suitable for their consumption, which prevents its being attacked by these promoters of putrefaction and fermentation. Our pears, after burning their substance for a time without any new supply, become weak, and fall an easy prey to their persecutors. The moment the soil is free there is no want of seed. I need not reopen the old question and repeat that every breath of air is full of it. It is said that if you want a thoroughly good pasture, the best way is to fallow your ground and leave it for thirty years. During that time you will have over it a battle-royal for life. Every possible kind of seed will come to it from the four winds of heaven, and for a time it will be a wilderness of weeds; but soon the good old law begins to work, and the weak go to the wall, and the fallow bears a close sward of native British grasses. The same takes place in our pear, only what takes thirty years in a field is compressed into thirty hours, and probably before a much longer time has elapsed, its surface is enveloped in a luxuriant microscopic jungle of *Mucor stolonifer*. WYVILLE THOMSON

THE FINDING OF LIVINGSTONE

How I found Livingstone in Central Africa. By H. M. Stanley. (London: Sampson Low, Son, & Co.)

MR. STANLEY'S bold march from Zanzibar to the Tanganyika, and his perfect success in meeting with and relieving the greatest of our modern travellers precisely at the right moment, will ever form one of the happiest and most romantic pages in the story of African exploration.

Remembering the watchword of his mission, "Go and find Livingstone," and that this, not the discovery of new countries, was his great object, it seems almost invidious to notice that Mr. Stanley's journey must take a minor place among African travels of exploration, adding little to our knowledge of the exact geography of the continent. The path which he traversed is for the most part a frequented caravan route, running parallel to, and occasionally touching, the lines passed over and described by Burton, Speke, and Grant. Without the basis given by the labours of these explorers, Mr. Stanley's work would have had but small value, since he himself has not made a single observation of position or of elevation, and the compass-bearings contained in some parts of his book are not in any way checked for magnetic variation. Still, very considerable portions of Mr. Stanley's route pass through lands hitherto untrodden by Europeans; some parts even unvisited by Arabs, and of these he is undoubtedly the discoverer.

Three frequented caravan routes lead from the coast near Bagamoyo towards Unyamyembe, and of these Mr. Stanley chose the most northerly and direct, the others having been traversed by Burton, and Speke and Grant. In following this new line, Mr. Stanley has been able to mark out more clearly than the former travellers the separate basins of the Kingani and the Wami rivers of the coastland; and he points out the important fact that the latter might be navigated with ease by light-draught steamers for a distance of 200 miles inland from the port of Whinde at its mouth.

At the base of a spur of the Rubeho mountains, the edge of the high plateau of Eastern Africa, the unexpected scene of a walled town presented itself. This was Simbamwenni, the capital of Useguhha, and the recently-built stronghold of an usurper, "another Theodore on a small scale"; "the houses in the town are eminently African; the fortifications are on an Arabic-Persic model; well-built towers of stone guard each corner; four gates are facing each cardinal point, and, set half-way between the several towers, permit ingress and egress to the inhabitants."

Beyond the mountains which face the coastland, Mr. Stanley's route converged in the dry region of Ugogo to that of Burton and Speke, and hence to Unyanyembe he passed over their track. Arrived at Tabora in Unyanyembe (the name Kazeh, applied to this capital by Burton, appears to be now unknown), Mr. Stanley found the whole country to westward overrun by the gangs of Mirambo, the turbulent chief of Ugoweh, a place some 60 miles north-west of Tabora. This chief sternly refused passage to the Arab traders unless they would aid him in a warfare he was about to wage against the Sultan of the Wanyamuezi in Unyanyembe. After taking part in an ill-directed and unsuccessful attempt to dislodge the obstructive Mirambo, Stanley determined to strike out for himself a new path outside the disturbed region. In carrying out this resolve he led the way, in a semicircular track of more than 200 miles, through the forest countries of Utakama, Ukonongo, and Ukawendi, first south, then west and northward to where he again fell in with the ordinary trade route. The whole of the geography of this detour is new and interesting, and it forms the chief portion of the discoveries which are particularly Mr. Stanley's own.

The path chosen lay round the southern tributaries of the Malagarazi river, the largest known tributary of the Tanganyika, and along the water-parting between this basin and that of the Rungwa river farther south, which Mr. Stanley affirms to be also an influent of the lake, flowing through the marshy plain called Rikwa (the Rukwa lagoon of Burton and Speke). The direction of flow of the Rungwa is a most important point, since it had been suggested as probable that the Tanganyika might have its outflow through this marshy country to the Lufiji river on the east coast. This theory appears now to have no foundation.

Passing over the arrival at Ujiji, and the most fortunate conclusion of Mr. Stanley's direct mission in meeting the great traveller there, the next perfectly new portion of this journey is that in which Livingstone and Stanley together explore the head of the Tanganyika.* "We found that the northern end of the lake was indented with seven broad bays." "The fourth bay (at the head of which was the delta of the Rusizi), was about three miles in depth, and penetrated half a mile farther inland than any other." "Soundings indicated 6 ft., and the same depth was kept to within a few hundred yards of the principal mouth of the Rusizi." "We ascended about half a mile, the current being very strong (from six to eight miles an hour), and

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* Mr. Stanley prefers the spelling Tan-gan-ika.