REMARKS

ON

HETEROGENESIS IN ITS RELATION TO CERTAIN PARASITIC DISEASES.

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AFTER their death, the bodies of both Animal and Vegetal organisms speedily begin to undergo processes of decay. When the functional processes in organs have come to an end, there gradually supervenes throughout the body a cessation of all those complex molecular movements which go on within, and essentially constitute the life of the ultimate constituents of organs and tissues. It is now well known that these intestine movements in the ultimate elements of organs (although suffering a marked diminution at the time when the organism itself dies) continue for a variable time in different tissues. So long as these movements continue, the individual tissue-elements must be considered to live. Gradually, however, the essentially vital changes and movements diminish, and then the ultimate molecules of the living tissues begin to undergo rearrangements and decompositions.

I have elsewhere (*Modes of Origin of Lowest Organisms*, 1871) endeavoured to show, by cogent experimental evidence, that when organic matter undergoes decay or putrefaction, a double process of composition and decomposition invariably occurs; *i.e.*, the complex organic substances break up into simpler binary compounds, during which the previously locked up forces are instrumental in bringing about new synthetic changes among other constituents of the organic matter. The new products thus evolved appear as specks of living matter, which gradually grow into *Bacteria*, *Torulæ*, or other simplest forms of life. Thus do "vital" processes lapse into ordinary chemical processes; and thus in turn do these chemical processes again give birth to "vital" combinations. In the present communication I intend to refer to other modes by which independent living units may arise in the bodies of dead or of living organisms; although what I have to say at present must be understood to derive most important extrinsic support from the experimental evidence contained in the little volume already mentioned, and from other evidence of a more conclusive nature not yet published—all of which tends, as it seems to me, most conclusively to show that living units may arise *de novo*, quite independently of pre-existing living matter, and therefore as a result of certain most complex chemical combinations.

These views, which I have been compelled to adopt, after a long and laborious series of investigations, differ little in their most important aspects from doctrines which have hitherto been current amongst certain biologists, although for some time the scientific foundation for such views was scarcely so strong as it might have been. My respected friend and colleague, Professor Grant, has comparatively recently given expression to views which he has long entertained, when, in speaking of animals, he says (*Tabular View, etc., of Recent Zoology*, 1861): "The great proportion of soft and fluid parts in animal bodies and their very complex constitution, accelerate their decomposition after death, when they mostly return their elements to the simple binary compounds, gaseous, fluid, or solid, of the mineral kingdom, whence they had passed into the plant. But a great part of their high vital forces, accumulated and latent in the living condition, or expended in maintaining that condition, now set free, manifest themselves in the production of heat, light, odorous emanations, and most of all in organising and vivifying the nuclei of myriads of monadine animalcules in the act of their formation from their fluid organic elements." And again he says (*loc. cit.*, p. 91) "the accumulated latent vital forces now set free effect numerous combinations in surrounding matter, evolving gaseous and fluid products, and preparing protophytic and protozoic cells to commence the same round of molecular mutations."

Whilst it may be possible that heterogenetic changes should take place in some part of the body, even of a healthy animal, provided the intimate vital movements and changes in that particular part are much lowered either accidentally or by the effects of local disease; it becomes much more common for such changes to occur in various parts of the body when the general "vital powers" are lowered by disease. And for a similar reason heterogenetic changes take place even more freely still when the organism itself is dead, and when its component parts are left to struggle on under the most adverse circumstances, till the little remote period when death overtakes them also. Then in all parts of the dead organism there appears a bursting forth into new life. Myriads of *Bacteria* and Fungus-germs are born from their parent fluids, although all this is hidden from our ordinary view, and only becomes manifest when the ever varying forms of "mould" and "mildew" appear and flourish upon the surface of the previous living aggregate.

For the most part I intend to confine myself to the consideration of the mode of origin of such lowest organisms within the substance of higher plants and animals. I do not propose to enter into the question of the possibility of the independent origin of any of the higher parasitic entozoa. The occurrence of these parasites was formerly regarded as one of the strongest points in favour of the doctrines of Heterogeny. But the investigations of numerous helminthologists have done much to remove very many of the difficulties, which were formerly regarded by Müller and others as almost impossible to be explained on the supposition that these organisms had been derived in the ordinary way from ova. The migrations and transformations of entozoa in the bodies of different animals, and our knowledge of the mode in which the embryos of cystic and nematoid parasites are enabled to penetrate the tissue, clear away many of these old difficulties. It must be confessed, however, that the truth of such new facts does not veto the possibility of the occasional independent heterogenetic origin of some of these organisms. I will merely state that such a mode of origin is still affirmed by Dr. Gros and others; and their views are countenanced by many cases in which such parasites have been found within the unborn embryos of higher animals, where their presence can scarcely be reconciled with our present knowledge concerning the powers and means of distribution enjoyed by these higher parasitic organisms.

It might be deemed probable that, if heterogenetic changes occurred at all in higher animals, these would be most prone to take place in some of the fluid or semi-fluid secretions, or else in some of those tissue-elements which are constantly bathed with albuminoid fluids—either on the external surface of the body, or on some of its internal surfaces. And this is found to be the case. No better, longer known, or more generally neglected instance can be alluded to than the transformation of milk-globules, under certain conditions, into large Fungus-germs, which speedily vegetate into a kind of *Penicillium*.

This remarkable transformation was described by M. Turpin thirty-four years ago, in a paper read before the French Académie des Sciences; but it has been for the most part disbelieved or unheeded by many who should have satisfied themselves by actual observation as to the truth or falsity of what had been recorded. With some rare exceptions, this seems to have been neglected, though the few who have looked for themselves have been able to confirm M. Turpin's statements.*

When a stratum of milk one or two inches in depth is placed in a small vessel (protected from dust by an inverted glass), the larger milk-globules soon begin to collect on the surface of the fluid. After twenty-four hours or more, the surface is found to be yellowish and smooth, constituting the most superficial stratum of a layer of cream, the under portions of which are of an opaque white colour. When reflected, this is found to lie on the surface of a bluish-white whey containing soft flakes, which, on microscopical examination, are ascertained to be composed of preciptated albumen in a finely granular condition, mixed with small milk-globules and multitudes of active *Bacteria*. In this condition, it has a sour odour and an acid reaction. The white stratum of cream immediately above is composed almost wholly of aggregated more or less unaltered milk-globules, mixed with myriads of *Bacteria*. But it is in the superficial yellow stratum more especially that the milk-globules are found to be variously altered, and that some are being metamorphosed into *Fungus*-germs. To recognise this satisfactorily requires some care and patience, and is only possible by making an examination of specimens in which the transformation is in its earliest stages. After even a few hours, owing to the very rapid growth and repeated branching of the *Penicillium*-filaments, the superficial stratum is permeated by them in all directions; and they are mixed up soon afterwards by the large conidia

* That a true appreciation of the responsibility attaching to the publication of such a fact was felt by M. Turpin, is obvious from the following passage. He says:—"Une découverte aussi inattendue que celle du globule du lait se développant et se transformant en un végétal était trop neuve pour pouvoir être annoncée avec empressement et légèreté; aussi ai-je répété soigneusement mes observations depuis plus de six semaines, en suivant heure par heure ce curieux développement, en en décrivant et en en dessinant avec exactitude toutes les phases successives comme on peut le voir dans les dessins très détaillés que j'ai l'honneur de mettre sous les yeux de l'Académie."—*Ann. des Sc. Nat.*, 1837 (Zoologie), t. viii, p. 349.

which the filaments are constantly throwing off, and which germinate in their turn.

In this stage, it is almost impossible satisfactorily to make out the primary mode of origin of the filaments, though it is quite different, when the stratum is examined at the period when the globules are just beginning to bud into filaments, or, what is better still, if the method originally recommended by Turpin be adopted. A drop of distilled water should be placed upon an ordinary glass microscope-slip; and to this a small quantity of the as yet unaltered cream should be added so as to disseminate its globules through the fluid. A covering glass should then be applied, and allowed to float somewhat freely on the fluid. After a microscopical examination of the specimen, with the view of ascertaining the state of the globules and the absence of all apparent Fungus-germs, the specimen should be carefully transferred to a damp chamber which is thoroughly saturated with moisture, so as to prevent as much as possible the evaporation of the fluid from beneath the covering glass. Or else the drop of water containing milk-globules may be left without a covering-glass, if it be placed in a small chamber thoroughly saturated with moisture. The specimen may then be examined from time to time with a $\frac{1}{12}$ objective; and in the course of from twenty-four to seventy-two hours, according to the temperature, such changes will have occurred in many of the milk-globules, ranging from $\frac{1}{10000}''$ to $\frac{1}{2000}''$ in diameter, that they may be seen to have assumed a less refractive and more distinctly vesicular appearance, and to be giving birth to one, two, or even three

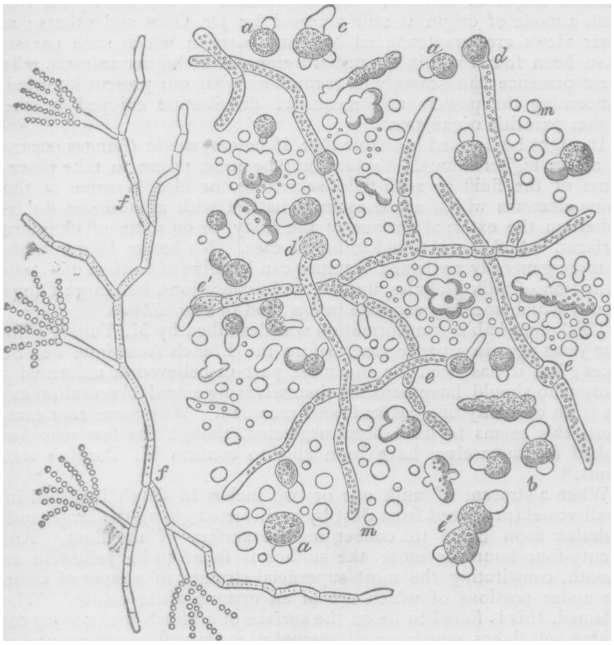

Fig. 1.—Conversion of Milk-globules into Fungus-germs (Turpin). ×450.
m, m. Unaltered milk-globules. *a, a.* Milk-globules which have become granular, throwing out a single bud. *b, c.* Globules with two and three buds. *d, e.* Rudimentary mycelial filaments growing from globules. *d′, e′.* Filaments in a more advanced condition. *f.* Specimens of *Penicillium* less highly magnified, but more developed and bearing spores.

buds, from their periphery, which speedily grow into large disseminated mycelial filaments.* All this was definitely described by M. Turpin when, speaking of the milk-globules, he said: "Lorsqu'ils se trouvent livrés à eux-mêmes et placés dans des circonstances favourables à la continuité de leur existence, ils ne tardent pas à se gonfler, à prendre souvent la forme irregulière d'un petit topinambour microscopique, et à germer par plusieurs côtes à la fois, de la même manière que germent les seminules vésiculeuses des Confervées, des Mucédinées, des Champignons, et des vesicules polliniques." Or, as I have also been able to ascertain, other globules, "au lieu de commencer par prendre un développement irrégulier deviennent ovoïdes, puis allongés comme de petits bouts de cylindre, et dans ces divers états, ou plutôt sous ces formes modifiées, poussent des bourgeons par l'une ou par les deux extrémités à la fois, et produisent également le même *Penicillium glaucum*" (*loc. cit.*, pp, 340, 342). The fact that so many corpuscles undergo a similar change beneath the same covering glass, that these changes take place in corpuscles which are so large as to be most easily observed, and that all stages may be detected between apparently unaltered milk-globules and the large Fungus-germs into which they are transformed, make these observations absolutely convincing to any one who has once witnessed them.* They therefore become typical of many other changes which may take place, but in which all the stages of the transformation cannot be so easily watched.

* Other globules become fused together so as to form large irregular masses of various kinds. Multitudes of *Bacteria* also appear amongst the globules.

Left to itself, the whole surface-layer of milk in a short times becomes densely interwoven with fungus-filaments; and amongst them are thickly sown multitudes of the conidia which they are continually throwing off. Soon a white mildew may be seen with the naked eye sprouting up from all points of the surface, which speedily becomes covered with a perfect forest of *Penicillium glaucum*.†

It seems probable, moreover, that somewhat similar changes may occasionally take place within the mammary ducts themselves when, owing to some diseased condition of the gland, the milk is long retained. A specimen of milk was sent to M. Turpin by M. Lassaigne which had been taken from a cow whose mammæ were somewhat inflamed and engorged; and this was found to contain a very large amount of fungus-mycelium. It is said: "Ce lait sortait des mamelons ou trayons sous la forme de petits flocons d'un beau blanc et d'un aspect entièrement cotonneux." And, on microscopic examination, these flakes proved to be masses of dense interlaced fungus-filaments, and of more or less altered and agglutinated milk-globules. So that one can only conclude, as Turpin (*Mém. de l'Acad. des Sciences*, 1840, t. xvii, p. 232) suggests, that "les globules laiteux, arrêtés et accumulés dans les voies d'un mamelle surirritée et engorgée, y avaient produit lorsqu'ils vivaient encore, les filaments byssoïdes et mucédinées comme cela se voit chez les globules laiteux abandonnées à eux-mêmes sous l'influence de l'air et de l'oxygène."‡

The valuable researches of M. Turpin on the milk of cows suffering from "cocote" (which seems to be an affection very similar to the "foot-and-mouth" disease) have revealed the fact that in the very worst cases the milk becomes horribly fœtid, and then swarms with innumerable moving particles, which are doubtless veritable *Bacteria*.§

This metamorphosis of the milk-globule may be most suitably compared with other heterogenetic changes which have more recently been made known by one of the most distinguished botanists of the day, M. Trécul, as occurring within the tissues of many flowering plants and shrubs.

It may easily be imagined that the aerial leaves of ordinary plants and trees are not favourably situated for the occurrence of evolutional changes in their interior. The living matter of which they are composed is exposed too much to the drying influence of the air, and to other adverse conditions, to enable it to give birth to anything save *Fungus*-germs, or similarly low organisms. And as for their internal tissues, the fluid or semi-fluid portions of these being cut off from the free access of air, and also distributed for the most part in small quantities through numerous separate and more or less closed cellular compartments, they are little prone to undergo any save the lower modes of organic evolution. *Bacteria* may be produced in abundance, and so also may low fungoid organisms, as we have learned from the investigations of M. Trécul on the laticiferous vessels and from the observations of many other workers.

M. Trécul having previously demonstrated the presence of a large quantity of starchy and nutritive material within the laticiferous vessels

* And yet, in opposition to the investigations of M. Turpin, extending, as he says over more than six weeks, and the positive statements which he was able to found upon them, one of our most influential authorities on such subjects is content to offer the following somewhat loose criticism:—"Without laying too much stress on the difficulty of following up the development of a single globule amongst a multitude, there can be no reason why spores of *Penicillium*, or at least particles capable of reproducing it, should not be present in the milk as well as the *oïdium* in diabetic urine. And though the true spores are of considerable size, it is more than probable that many moulds—as, for instance, such as grow on paste, decaying meat, vegetables, etc.—assume on their first development a form very different from that of the full-grown plant."—Berkeley's *Introd. to Crypt. Bot.*, p. 260.

† In view of the observations just detailed, it becomes a most significant fact that precisely the same kind of fungus is apt to spring up on all sorts of organic matter when it begins to undergo processes of decay. As Turpin says, one may now conceive that "indépendemment des moyens reproducteurs secondaires, tels que ceux de la séminale et de la bouture, le *Penicillium glaucum* peut se montrer avec une étonnante profusion partout ou se rencontrent les globules producteurs de la matière organiques."

‡ M. Turpin, moreover, suggested that a similar germination of the milk globules might take place occasionally in women after child-birth, when the exit of the milk is delayed and the breast is irritated and inflamed.

§ *Loc. cit.*, p. 228. M. Turpin also makes known the interesting fact that, in the same cow, the milk from different teats may be totally different in quality (p. 214); and that the consumption of the milk of cows less severely affected was not appreciably deleterious (p. 237).

of many plants—or, at all events, of a substance which is capable of being easily converted into starch—was therefore the better able to explain the following phenomena. In August 1860, some fragments of *Apocynum cannabinum* having been placed in water, in order by maceration to isolate the laticiferous vessels, the latex within these at first underwent its accustomed alterations in appearance. The small globules which it usually contains, united either into larger globules, or else into masses of a more or less homogeneous character. At a later stage all this latex had undergone a new change; it had become finely granular, and there only remained here and there, as relics of the former condition, minute portions of the old homogeneous material. M. Trécul says (*Comptes Rendus*, 1865, t. lxi, p. 158): "This was of itself a sufficiently singular occurrence. But my surprise was great when, after having placed these laticiferous vessels in contact with iodine and sulphuric acid, I saw their whole contents become of a deep violet colour, whilst the little masses of latex which had not undergone this last change, and which were enveloped by portions of the juice that had become thus finely granular, remained uncoloured, or else had assumed the yellow colour which iodine frequently communicates to the latex......... Having then directed my attention to the fine newly formed granules, I perceived that they were more extended [*plus étendues*] than they at first sight appeared, since each violet spot was, in certain vessels, only the termination of a little oblong body, either colourless or slightly stained yellow, and which was composed of two or several cells. Elsewhere the other cells of this little organism were more feebly-tinted violet, or else all were alike intensely tinted."

A closer examination of these bodies has shown them to be organisms which differ considerably in size and shape on different occasions. They present themselves as very minute globular bodies; in the form of small cylinders, either simple or capitate; as larger elliptical corpuscles, which may elongate into fusiform organisms about 1-5000th of an inch in length; or, lastly, as corpuscles with a projecting shoot. Some are motionless, and others display slight undulating movements. These bodies, from becoming variously tinted by iodine, show that a starchy matter is produced during their metamorphosis and growth. Owing to this fact, and on account of the resemblance of many of them to *Bacteria*, they have been included by M. Trécul under the name *Amylobacter*.

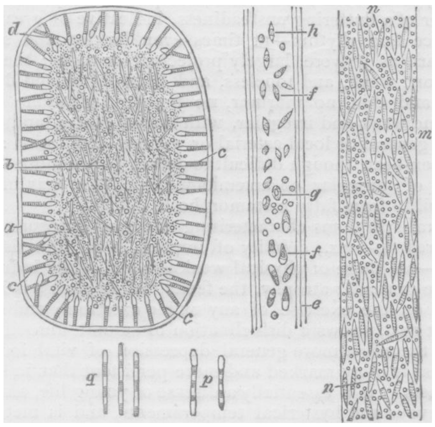

Fig. 2.—Origin of *Amylobacter* within cells and laticiferous vessels of Plants (Trécul). X520.

m. Portion of a laticiferous vessel of *Amsonia latifolia* whose contents have been transformed into fusiform *Amylobacters*. *a.* Medullary cell of *Ficus carica* filled with granules and fusiform *Amylobacters* (*b*), and having other larger capitate *Amylobacters* upon its internal wall (*c*). *e.* Portion of thick-walled bark-cell containing different forms of *Amylobacter*.

In other vessels, such a change, instead of having been effected throughout the whole vessel, was, as it were, still in progress. "One part of the column of latex had become purple from the action of the iodine and sulphuric acid, whilst another had become yellow; but from the one to the other tint every transition was to be seen........... Some other unbroken vessels were very instructive, inasmuch as their latex, not being modified to the same extent, assumed a yellow colour under the influence of the reagents; only corpuscles (cells) of a violet colour were dispersed throughout its interior, and often they were all quite separated from one another." M. Trécul adds: "*It is important to note that I did not find any of these little organisms dispersed through the liquid which surrounded the laticiferous vessels.*" To account for the presence of the organisms under such circumstances, only two suppositions seem possible. As M. Trécul says: "Either they are born from germs proceeding from without, or else they proceed from a modification of the elements of the latex. If they owe their origin to pre-existing germs, how are these germs introduced by thousands throughout the whole length of vessels filled with a dense fluid—so consistent as to be no longer able to flow—to such an extent as completely to substitute themselves in the place of the juice itself? How can any one conceive, whilst admitting such an invasion of germs, that small islets of latex should have remained intact here and there, and should have been able to resist this invasion which pressed round them on all sides? Is it not at least as probable that these organisms may have been born from a transformation of the latex?"

In a subsequent communication (*Comptes Rendus*, t. lxi, p. 432), made in September 1865, M. Trécul reported that he had confirmed the results previously arrived at by fresh observations upon similar plants, and also upon others belonging to different families. In one of these, *Ficus carica*, he had even discovered similar starch-bearing fungoid organisms within the completely closed cells of the medullary tissue—a fact which seemed to make their mode of origin even more certain than it had been before. Some of these cells contained nitrogenous matter, which still became yellow under the influence of iodine; others contained only a perfectly homogenous liquid; whilst in a third set, otherwise similar to the last, there was a bubble of gas in the centre of the liquid cell. The fungoid organisms were seen only in cells that were in one or other of the two latter conditions. In some situations they were something like tadpoles in shape, whilst in others they were cylindrical, or only very slightly attenuated towards one extremity. But M. Trécul tells us—and no one is more competent to pass an opinion on such a subject—that "the appearance of these little plants within closed cells, occupying their natural situation in the very middle of the medullary tissue, negatives all ideas as to the introduction of germs from without." He has even seen similar organisms produced within fibre-cells of the bark, after they had become notably thickened, both in *Asclepias cornuti* and *Metaplexis chinensis*. He has also watched all the stages by which they arise in the intercellular spaces.

But M. Trécul is able to add another proof even more striking than any we have hitherto mentioned. He has actually seen a crystalline mass undergo modifications, and become itself converted into an *Amylobacter*. There exists, he says, in the bark of the common elder, and in that of plants belonging to different families, such as *Solanaceæ* and *Crassulaceæ*, a number of cells which are filled with little tetrahedrons, having slightly unequal sides. These cells may be isolated, or they may be grouped in contact with one another, and in longitudinal series. The cell-walls sometimes become partly absorbed, so as to form intercommunicating lacunæ, and it is within these that the enclosed tetrahedrons become converted into starch-bearing organisms. M. Trécul says: "Since my observations in 1860, I had become aware that corpuscles, which coloured violet under the influence of iodine, frequently replaced the tetrahedrons after putrefaction; but, at this period, I had not seen the transition from the one to the other. I was more fortunate this year. I have seen the tetrahedrons themselves, containing amylaceous matter, forming columns, tinted of the most beautiful violet colour. I have seen the tetrahedrons become elongated at one of their angles, and pass gradually into those curious little plants, by producing a cylindrical outgrowth. In this case, the rounded or still angular tetrahedron represented the bulb, but the tetrahedron occasionally became completely obliterated, and left in its place only a little fusiform or cylindrical vegetable organism."

This is, indeed, an example which, in point of certainty and freedom from possible sources of error, to a skilled observer, seems almost unsurpassable. If a person sees a crystalline mass of matter slowly alter its form, and become bodily converted into a vegetating organism, he could not have evidence of a more convincing nature. Only one explanation of such a fact is possible—hence M. Trécul is quite entitled to say (*loc. cit.*, p. 435): "De tous les faits qui précèdent, il résulte que *la matière organique contenue dans certaines cellules peut se transformer pendant la putréfaction, en corps vivants de nature très-différente de l'espèce génératrice.*"

[*To be continued.*]

We are inclined to think that "carbon-closets" are an improvement on "earth-closets"; and those who wish to know more about them will find them well described in a paper read by Mr. E. C. Stanford before the Mechanical Section of the British Association at the Edinburgh meeting, and published *in extenso* in the *Chemical News* of February 6th.