IX.—*The Bacteria of Davaine's Septicæmia.*

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The organisms here shown under the Microscope, and which occur in the blood of the rabbit, in the form of septicæmia known as that of Davaine (one of the first who described it, about twenty years ago), are remarkable, in many respects, from a microscopical point of view, and possess a general interest from their relation to the affection in which they occur, and which has been regarded almost as the type of a specific parasitical disease, from the circumstance that the blood of an animal in these cases is infective in inconceivably small quantities. The statements of Davaine on this point, which attracted so much attention, were that the trillionth,* or the ten-trillionth part of a drop of this blood was infective.

His experiments were repeated by several observers, who confirmed his results in different degrees. I have myself found, in numerous experiments, that in the case of rabbits the blood is usually infective up to the millionth and the hundred-millionth part of a drop; sometimes in even smaller quantities, obtained by successive dilutions.

In such blood I have found that the organisms here described always occur, but in very variable numbers; in some cases not more than one or two are to be found in each field of view, in others they exceed many times the number of the blood-corpuscles; they do not appear to increase in any marked manner shortly after death, as is the case in some other affections. The microphyte itself is a form of *Bacterium*, in the generic sense of the term, as defined by Cohn; its diameter, which varies less than that of any other form of Schizophyte which I have examined, is just over half a micro-millimetre (0·509 μ), almost exactly $\frac{1}{2000}$ m. The length which, in different stages of development, is very variable, may be put down at from 1½ to 2, 3, or, in a few cases, 5 times the diameter, that is, of the single cells, or rods as they are commonly termed; two or three of these, but not more, sometimes occur united together, endwise, forming short chains; but they never, in the blood of an animal, form either long leptothrix filaments or zooglœa masses. They frequently appear in the form of a figure of 8, or a dumb-bell; this, as is shown in stained preparations—an example of which may be seen in the field of view under the Microscope—is not due to a constriction of the cell-wall, indicating incipient fission, but to a difference in its constituent parts and their refractive power; the

* A trillion in the French notation is a billion in the English, i. e. a million squared.

two ends are the most highly refracting, they take the staining more deeply than the intermediate portion, which is often with difficulty perceptible; the ends thus stained present the appearance of forming spores, in some cases so distinctly that I am disposed to think this is really the case, though I have never witnessed their complete development.

The preparation shown is from the blood of a rabbit of the third generation of artificial infection, it was made very shortly after death, and treated by the methods introduced by Weigert and Koch, which have been described elsewhere, and are now pretty generally known and adopted. I have not found these Bacteria in any of the organs or the tissues, excepting the blood and the lymph of an infected animal, examined immediately after death, not even in the lungs or the spleen, where, judging from other cases, we should expect to meet with them; their minute size, however, and more especially their not readily staining, would render them very difficult to distinguish in the tissues. In the blood this *Bacterium* is evidently motile, sometimes very actively so.

Notwithstanding the interest and attention which this affection has excited during several years, and the importance of the microphyte in relation to the question of the true nature of the contagium, it has not, I believe, been figured or at all carefully described by any one, excepting only by Coze and Feltz, in a work published at Strasbourg and Paris several years ago; their description is imperfect, and does not in any way coincide with my own observations; they even give the diameter of the organism just three times as great as I have found it. These measurements I have checked by the use of the admirable standard stage micrometer recently constructed by Professor Rogers, of Cambridge, U.S.A., one of which I have received, and which is most valuable in enabling different observers to compare exactly their measurements. The immense discrepancy, however, between my observations and those of Coze and Feltz, cannot be reconciled by any variations in the standard scale used, and renders it difficult to believe that the same organism has been observed in the two cases. This opens up a very important, indeed a fundamental question with reference to the etiology of this affection, which need not be discussed here; I will only say that in the course of very numerous experiments, in different series, I have found the organism specifically distinct, invariable and constant in all cases, thereby conforming to the first and most important condition which has been laid down as a test for a specific parasitical contagium.

In relation to the dimensions of the organism, and the infective virulence of the blood in which they are contained, a very curious question arises as to how many Bacteria or their germs can be contained in a given quantity of blood, and this, as far as I know,

has never been yet considered or referred to. Taking the dimensions of the Bacteria to be, diameter 0·5 μ, which is a fraction less than the actual measurement, and the length to be 2 diameters, which is undoubtedly under the average, a very simple calculation shows that in a drop, taken as the 16th part of a cubic centimetre, there would be 250,000,000,000 (two hundred and fifty thousand million), or just a quarter of a billion; this would be when the blood was entirely filled with, or rather replaced by a solid mass of Bacteria, leaving no space at all for the blood-corpuscles and but little for the plasma; and this is the utmost number which a drop could contain. I think it is evident, therefore, that there is some fundamental error in Davaine's statement and in that of those who have followed him, on this point. I have endeavoured directly to enumerate the number of Bacteria present in different portions of blood, but I cannot pretend to have succeeded with even approximate accuracy; the greatest number I could enumerate or estimate was a few millions in a drop.

Another point of special interest in this affection is the asserted increase in the infective virulence of septicæmic blood in successive generations of transmitted infection. This theory was explicitly maintained by Coze and Feltz, but Davaine's statements on the subject have been somewhat misunderstood, for although he asserted this in the fullest extent at first, he ultimately qualified the statement in some measure by showing that the maximum of virulence is reached very early; subsequent observers overlooked this qualification, and repeated and even improved upon Davaine's original statements. This question has again lately attracted attention in connection with the relation of micro-organisms to disease, and the sensational and, were they to be credited, appalling statements that have been made, and even supported, by high authority, asserting a transformation of physiological species in some of the lower organisms, which hypothesis, it was supposed, might be connected with or account for an increase in infective virulence in the organisms present in septicæmic blood in successive generations. On this point I shall only say that I have found in a long series of experiments recently made, that although the infectivity of such blood may be slightly variable, there is no such thing as progressive increase of virulence in successive generations; the blood of the first generation is actively infective in the millionth or the 100-millionth of a drop, or less, and it is not, and indeed for the reasons already stated, cannot be infective in very much smaller quantities, in the 25th nor any succeeding generations, nor is there any shortening of the incubation period, which in the large majority of cases is remarkably constant, ranging from twenty-one to twenty-four hours.

The relation of the organisms here described to the disease in

which they occur, has recently been the subject of experiment in Germany; I shall only say with regard to this that on investigating this question, it appears to me clear that the *Bacterium* does constitute the specific virus, the actual contagium of the affection.

The importance of the relations of these microphytes to disease, and indeed their rôle in the whole economy of nature is now so generally acknowledged that it is unnecessary to dwell upon it. It is only quite recently that the subject has been systematically developed, and already most valuable results have been attained, some of which, in regard to a most important practical application, viz. to tubercular disease, have only been communicated during the last month, and demonstrated in this College in the present week. It is by the microscopical examination of the organisms and the determination of their specific morphological characters alone, that many of the most weighty questions which present themselves can be determined. There is no field of microscopical research which requires more care or better optical appliances than these organisms, and none more worthy the attention of microscopists.