NOTES
ON THE
SPIRILLUM FEVER OF BOMBAY, 1877.

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ALTHOUGH the town of Bombay is not situated within the area in Western India lately the seat of scarcity and famine, yet it has suffered in an indirect and, so far as appears, a peculiar manner; for the crowds of indigent peasantry, flocking thither, brought in their train not only destitution and overcrowding, but also a contagious fever, which soon spread to the resident population immediately in contact with those famine-stricken people, and became the cause of death to many persons.

That this fever (which after a year or more, yet lingers amongst the poorer classes) is identical with the "hunger-pest," "famine- or 'relapsing-' fever," or the so-called "recurrent-typhus" of Europe, I hold to be now fully demonstrated; and this fact I regard as one of great significance in Indian pathology. The demonstration just referred to has resulted from the combined use of the clinical thermo-

meter and microscope; and I am not aware of any data invalidating its force. Assuredly, the negative circumstance of the same fever not having been detected in other parts of the Bombay Presidency, or in the famine districts of Madras, can in no way detract from the weight of positive proof acquired in the western capital. Such proof is as follows:—

1. The rather abrupt appearance of a malady evidently connected with unusual and excessive want, fatigue and overcrowding; its spread with the increase, and subsidence with abatement of these hygienic defects. 2. The remarkable resemblance in clinical characters of this new malady with the relapsing fever of Europe, a resemblance so close as of itself to be decisive of actual identity. 3. As a special feature, the invariable presence in the blood, during pyrexia, of a minute parasite which, so far as known, is peculiar to one form of fever only, viz. the relapsing.

Thus there are combined the natural history of an epidemic, the symptoms of a fever and the pathology of blood-contamination; each of these fundamental features displaying special characters pointing to but one conclusion.

And almost equally significant with the above, as regards diagnosis, is the observation that this new fever raged most at that season of the year when malaria least of all abounds. I should add, too, that antiperiodic remedies, such as quinine, had no influence in checking recurrence of the febrile paroxysms.

Respecting the first or natural history proof, just offered, I have to observe that its force depends upon the contemporaneous outbreak of the epidemic and the excessive influx of famine-stricken people; it is well known, too, that as the pressure of immigration augmented, the 'fever' death-rate rose; and, lastly, it can also be shown that contemporaneously with diminished influx, and with active deportation of many families to relief centres in the interior, this comparative fever mortality began to decline; though had it been due to malarious influence alone, the reverse would have been the case. Data in support of each of these statements, must be deferred, but in what is now submitted there

is nothing that is inconsistent, and much that is in accordance with accepted inferences derived from European experience. And with reference to the view of the Bombay epidemic being essentially connected with defective sanitation, I would remark, first, that there is no evidence of contemporaneous increase of mal-sanitation, and next that relapsing fever is not one of the diseases usually attributed to filth.

The evidence upon which most stress will be laid, is, however, that included under headings two and three, which treat of symptoms and pathology equally characteristic and conforming; this kind of proof is already available.

Before proceeding to details, I would first state the reasons why the term 'Spirillum-fever' has been chosen. Here, I am aware, the designating word is not quite correct (the Bacterium genus being "Spirochæte"), but it is preferred for euphony's sake and is hardly liable to mislead. The fever itself does not affect exclusively the hunger-stricken, and is neither limited to, nor the constant attendant of, famine times or places; it by no means invariably relapses; and it is commonly viewed as distinct from 'typhus'; hence the desirability of inventing a more suitable name, which if not adopted in Europe, at least might displace in India that of "remittent fever" hitherto employed.

As another prefatory remark, I would add that previous to last year I had no personal knowledge of the so-called relapsing fever; and that all now submitted is the result of considerable individual effort, a fuller expansion of my notes being necessarily reserved. It may be hoped, too, that the present enquiry will be supplemented by others made in India, where, it is right to state, the correct diagnosis of the new Bombay fever was made independently by more than one observer. I have much pleasure in acknowledging here the valuable co-operation of my two junior colleagues at the Jamsetjee Jejeebhoy Hospital—Mr. Succarani Arjoon and Dr. Anna Moreshwar K,—who proved themselves to be expert microscopists.

Clinical notes; introductory and general.—Information

was collected, 1st. in the camp of refuge for fever patients opened last April (1877) and closed after too brief an interval; notes of forty-eight cases hence, several being quite typical, are now before me. 2nd. In the wards of the Jamsetjee Jejeebhoy Hospital, where most instances of the spirillum fever and contemporary pyrexias were seen, a sum of about 700 cases having been examined; and 3rd. At the Goculdass Tejpal Hospital, also under my charge, where the beginning and later pursuit of the enquiry have been conducted: at least 100 cases of fever were hence derived.

Analysis of these data shows that we have recorded upwards of 350 examples of the spirillum-fever (C); about the same number of "fevers" mostly remittents and ague, in which the blood-parasite was sought for during the presence of pyrexia, but not found (B); and lastly, a considerable number of instances of mild and transitory febrile attacks, together with sequelæ of earlier illness, in which microscopic scrutiny of the blood was not attempted (Class A). As far as was practicable I examined every case of marked "fever," making no other selection than that of decided pyrexia at some period of the illness; and the enquiry extended from April to December, 1877.

The above statement shows that upwards of one-third of all hospital—and hence, perhaps, all, ordinary—cases of "fever" were demonstrably of the so-called relapsing type (C); and large as this proportion seems, it doubtless falls short of the truth, because there are numerous instances of fever amongst the classes marked A and B, which presented a clinical history and symptoms altogether accordant with the same type and not accordant with malarious forms. I have little hesitation, therefore, in assuming that the larger part of the late serious epidemic in Bombay, was due to the presence of the so-called famine fever.

The facts just summarised have also convinced me that both "remittents" and "intermittents," in all their usual shapes, are to be distinguished by the invariable absence of blood-spirillum, once, indeed, I found a minute and active organism in the blood of a patient effected with fever seem-

ingly intermittent in type; but in general I conclude that the spirillum must be regarded as distinctive of one clinical pyrexial form. This being affirmed, I am free to remark that, previously to late Indian experience, I had but a very imperfect conception of the multiform phases and degrees which the spirillum fever may assume, for about 25 per cent. of instances could properly be termed "irregular;" and, obviously, such experience, while in accordance with late observations made in Europe, is valuable, especially to practitioners in tropical countries where fevers termed "malarious" (with their equal variety of phase) do commonly abound. European writers have briefly but clearly commented upon the similarity of symptoms between isolated, secondary, and later paroxysms of relapsing fever, and intermittent or aguish attacks; and some have owned the impossibility of distinguishing between the two series from ordinary clinical observation. Quite independently, I had myself arrived at a similar conclusion in Bombay, where it was not at all uncommon to witness a single, or even repeated, one-day febrile paroxysm, which stood in the place of a relapse, but which did not present the blood-spirillum; and on the other hand, we noticed brief and isolated paroxysms or relapses, seemingly identical with the above, during which the spirillum was readily found. In explanation of this seeming discordancy, we may, as regards the negative results, suppose either that the blood was imperfectly examined; or that ague had, in fact, complicated the case. Experienced observers in Europe would doubtless adopt the first supposition, and not without reason; but in India we hold that a malarious taint is so widely diffused that an aguish attack may be excited by almost any kind of constitutional disturbance, and hence, by that of spirillum fever. The chief difficulty in adopting this view is the fact of the non-spirillar relapse in question commonly being true to time, and so giving rise to the impression that it stands in place of a veritable relapse. This interesting topic can be best discussed with the aid of charts, which at present I am unable to transmit, and hence must be content with the statement

that, on the whole, we have not in India secured valid evidence of intermittents (which I regard as the type of all periodic fevers) being, either partially or wholly, substitutory of the spirillar-paroxysms. That ague may precede, accompany, or follow the spirillum-fever, and that each of these types may possibly predispose to the other, I should not hesitate to admit; but until we find in the blood of individuals affected with ague, an organism comparable to the spirochæte, it would be premature to assert a generalisation plausible only in theory. I have met, indeed, with an instance which seems to support the view of an essential connection between the spirillum-fever and intermittents, and which is certainly remarkable; but as it is also as yet single and seemingly exceptional, this subject may stand over for the present.

There exist, however, more important general resemblances. So far as I know, single, primary, and more pronounced attacks of the spirillum-fever, when free from complications, never assume the character of an intermittent, but they may often be compared with paroxysms, more or less restricted, of the "remittent" type. The pyrexia in a typical example of spirillum-fever may, indeed, be "continuous" in character; but it is, at least as often, distinctly "remittent," or both remittent and intermittent, so varying is its intensity in some instances. Were it possible to conceive of brief remittents which periodically relapse (I have never seen anything of the kind) then it might be difficult, at sight, to distinguish them from the true spirillum-fever. The use of the microscope would, however, dispel the illusion, which might also be dissipated by careful attention to other symptoms besides that of temperature, and to the natural history of the complaint.

Again, the interval or apyrexial periods of spirillum-fever may be so filled up, as it were, with daily changes of temperature as to render it by no means easy to make out the date of true relapse or even its cessation; nor is this filling up necessarily due to local inflammation, at least there may be no appreciable signs of the latter, and one seems obliged to

assume a previous malarious taint which has become roused into action, as it were, and so complicates the newer specific fever. Repeated scrutiny of the blood will serve to establish the times of appearance and disappearance of the parasite; but too few of these remarkable cases of prolonged fever, attended with single or recurrent development of the spirillum, have been seen to enable me to decide upon other diagnostic signs; only, as regards the late epidemic in Bombay, I acquired the impression that it was "typhus" rather than a "remittent," which is apt to complicate the spirillum-disease. In practice, the latter was found to maintain its periodicity, high temperature, and blood-contamination under all conditions, *i.e.* whether complications existed or not; and this feature serves to indicate its true special character. The most apparent symptom, namely, high temperature, is not, however, its most constant mark, for I have known the complicated specific paroxysm to be attended with, at first, rather a diminution of fever-heat, with a greater variation in its course, and at its close with a decided fall of temperature, the spirillum then ceasing to appear in the blood notwithstanding the prompt resumption of high fever, and reappearing only with a relapse. What is known as "the typhoid state" was, under various conditions including those of remittent fever, sufficiently familiar during the epoch under review; and when fever cases were first seen in this state practical difficulties were found in their diagnosis. Under such circumstances attention was given to the previous history, and search made for special signs or symptoms, local and general: microscopic examination of the blood never being omitted, and furnishing results which, even if negative, were commonly useful. Detection of the spirillum always, in my mind, inclined to a more favourable prognosis than might otherwise have been made, due watch at the same time being maintained for complications, and for that sudden collapse which often attends the disappearance of the parasite and the inauguration of convalescence. I do not regard the effect of quinine in these advanced cases as by any means necessarily diagnostic; the drug was freely

administered, but, as before intimated, it has no specific action in the spirillum-fever. The difficulty of distinguishing the latter complaint from fever symptomatic of local inflammation as well as from remittents attended with complications, may, when the use of the microscope is neglected, lead to fresh confusion which is not removed by an autopsy. Thus, for example, I have known "pneumonia" to be entered as the name of the disease, when it is morally certain that the case was one of specific fever early complicated with lung inflammation.

Illustration of these remarks (which might be extended) could be afforded only by citing individual cases; I therefore simply add that considering its multiform phases, (only newly learnt by us) it is hardly a wonder that the late epidemic has been prominently regarded as belonging to the malarious remittents; yet I am bound to add that this identification is not held by those practically acquainted with the disease, and it is much to be regretted that "remittent fever" remains as the official designation of a malady wholly different in origin and character. Were it only, indeed, because of the almost infinite confusion which lurks under this nosological heading, being thus rendered more confounding, it would be well not to delay a much needed remedy, but rather begin with the elimination of so marked and important a complaint as that of "relapsing-fever;" and then other just discriminations would follow—those of "leprous" and "elephantoid" fever being already practically acknowledged. I may here note that during an attack of obscure elephantoid fever the blood *filaria* was to be found, but on subsidence of the pyrexia I could no longer see it; here was evident an analogy with the spirillum fever.

A final remark will complete this cursory review of fevers simulating or complicating the new Bombay form; I refer to the continued or typhus type, of which there have been seen some unmistakeable illustrations. And first as regards certain remarkable connecting links, I have to record that both at the height and towards the close of the epidemic (my experience points oftenest to the latter) cases occurred

which had all the characters—the blood spirillum included—of the so-called “typhus ictërodes” or “bilious typhus,” in a most pronounced degree; instances are known also of the equally fatal type “hæmorrhagic typhus;” and in short our late experience here has been in striking accord with that acquired in great European epidemics. Many cases, too, of single or abortive spirillum-fever—not to allude further to severer examples—have presented an amount of constitutional depression which, in my estimation, would almost justify the designation of “typhus,” notwithstanding the absence, or seeming absence, of some cutaneous hæmorrhage or mottling. As a rule, however, unless there be seen indications of the characteristic temperature changes in some part of their course, it would be futile to search for the spirillum amongst instances of high and prolonged pyrexia (the only exception I have met with, was not seen until at a late stage); and when a fever can be said to have assumed other specific characters, *e.g.*, such as “typhus,” the parasite in question will, most probably, not be found.

This remark holds good of enteric or typhoid fever (in which with one very doubtful exception, the spirillum was never found), and I may add of small-pox and varicella, and numerous symptomatic fevers whether isolated or occurring as complications.

From what has now been advanced it will be evident that the subject in hand is by no means so simple as might at first sight appear, and in attempting to unravel this intricacy it would, perhaps, be best to recognise the entire pyrexial condition itself as a common character of several affections, each of which has as well its special features in mode of origin, local lesion, course, or termination. This view would imply a certain wider bond between all fevers, whether idiopathic or symptomatic, and a closer one between those commonly termed “specific,” wherefrom one might hope for general illumination by particular inquiry. Certainly, the characters of the spirillum-fever are, as it seems to me, very comprehensive, combining, as regards malarious fever, the intermittent (through its marked periodic tendency) and the

remittent (in its sustained paroxysms), and occupying an intermediate position also—through its connection with typhus—with the continued type of fevers; characteristic, too, is the remarkable clearness with which the attendant, if not causative, parasite is displayed in the blood, and hence, with unusual confidence, we may anticipate substantial benefits to pathological science from the thorough study of this particular form of “fever.” Amongst other topics of inquiry I would indicate the desirability of establishing the “type” of spirillum fever, or, in other words, of ascertaining the conditions of relapse; so varied, too, are the phases of this most interesting malady that I would ask, ought not the fever to be regarded, like those due to malaria, as embracing a “class” of ailments? And, lastly, there is the question of its true affinities.

Symptoms, mortality, and pathology.—As virtually a new disease in Bombay, interest naturally attached to every part of the clinical history of the spirillum-fever; and in practice interest ripens into importance, for the fuller our knowledge of details, the better able we shall be to recognise and adjust such anomalous and obscurer symptoms as are often presented by patients who are first seen at intermediate or later stages of their complaint. Usually, however, the sick came in not with sequelæ or complications, but towards the close of the first paroxysm or interval, and then the relapse alone was seen in full. The entire series of phenomena was visible only in the case of hospital servants and apprentices, and of patients freshly attacked in the wards. My own case, too, was a fair example of moderate severity, and of all these complete instances I may say that their symptoms entirely correspond to the classical descriptions of European authors, the variations therefrom being no greater than the inter-variations found in Europe itself. Thus, the attack was sudden and unexpected, the introductory chills not very marked, the fever at once high and then continuous or but imperfectly remitting; there were frontal headache, giddiness, and aching pains; much weakness, thirst, and nausea; sleeplessness, restlessness, and not seldom towards the end of

the paroxysm some delirium at night; constipation and yellow tinge in the conjunctivæ; abdominal fulness and epigastric uneasiness; the spleen and liver also participating: when at its height, about the seventh or eighth day, the general distress abruptly came to an end, with critical sweating and considerable fall of temperature—in my own case from 103° to 96° Fahr., but I have witnessed a descent of 10° and 11° within a few hours, attended with most pronounced collapse. The apyretic interval now begun allows of complete rallying, if not convalescence; thus, in four or five days I was able to leave my room and take a short walk, but on the eighth day a relapse came on, and shortly the temperature rose to 105° , falling later to 95.8° ; with the pyrexia again came headache, pains, sleeplessness, and wandering, such weakness that actual syncope was induced by the upright posture, an enlarged spleen and vomiting, with diarrhœa; the feet were puffy. In three days the crisis occurred, with a very sharp rise immediately after, and next day a temperature oscillating about the normal. An imperfect second relapse was noted and convalescence was protracted. The blood-spirillum abounded during the first paroxysm (as, even during the fever, I was able to make out), and this fact confirmed the diagnosis which rather suddenly flashed upon me with the recollection that I had a few days before scratched my finger at the autopsy of a patient affected with this fever. Inoculation, however, is by no means necessary to infection, and my state of health, weakened by long exertion, may have predisposed the system to disease at the end of six months' continuous exposure.

Diverging from these plain instances of fever with one relapse, we find, on the one hand, attacks in which no relapse occurs—and these, more frequent of late, have amounted to about 25 per cent. of milder or recovered cases; if, however, instances fatal during the first paroxysm be added, these, no fewer than 40 per cent. of attacks of the spirillum-fever in Bombay, did not show a relapse. On the other hand, there may occur two, three, or four relapses; and long subsequently

a renewed attack of the fever. Taken on a series of 177 cases not fatal (the addition of deaths would make no material difference) 57 per cent. of all instances were known to relapse once, 6 per cent. twice, 5 per cent. thrice, and 2 per cent. four times. In my estimation these figures alone would dispel the idea of comparing the new Bombay fever to any form of "remittents;" and further to show its identity with European famine-fever, I may observe that the mean duration of the first paroxysm was seven to eight days, the range being four to ten days; when a relapse took place it was after an interval of a week or so, and it lasted four to five days, with a range of one to seven days. No difference was noted between the abortive paroxysm and that followed by a relapse, and no fixed relation was observed between the severity of first and second paroxysms.

Repeated attacks of spirillum-fever in the same individual, after an interval of a few weeks or months, were well known in Bombay, but it was impossible to say whether or not they were due to a fresh infection.

Briefly adverting to individual symptoms, I believe there is no feature peculiar to Indian experience. Prodromata seem to be rare, and they were not mentioned in an instance where I found the spirillum about an hour after chills and the beginning of pyrexia; in my own case they were not noticed, and it may be said that relapses in general are seldom preceded by admonitory symptoms. These facts are worth attention, because one would anticipate some systemic disturbance with onset of the parasite, in its earlier stages of development.

The dark flushed, dusky and helpless physiognomy of fever patients became very familiar to us; a peculiar faint odour from the body was at times perceptible; in my wards a pink-coloured eruption (at first resembling the typhoid) which might become permanent, was not uncommon and petechiæ were present in severe cases; also sudamina and occasionally herpes and bullæ; the pulse and temperature ranges were absolutely identical with European standards; the weakened systole was common; œdema of the feet frequent; and

also pulmonary congestion. The tongue was dry and brown oftener than is indicated in European experience; it might remain so during the first days of a pyretic interval, coexisting probably with delirium and other typhus symptoms. Epigastric tenderness was not necessarily connected with vomiting, nor hepatic enlargement and tenderness with jaundice; the spleen was seldom tender on pressure, but I have seen the reverse when after death there was no "splenitis;" this organ is subject to rapid changes of volume and with acute enlargement vomiting has been noted. Both hepatic and splenic implication were most frequent and decided during the relapses. Jaundice was commoner here than it usually is in Europe; and the same remark applies to delirium, which was often acute, and marked by a suicidal tendency (two of my patients destroyed themselves by jumping out of window, within a few days of each other; yet in neither case was the delirium turbulent); deafness was a not infrequent sequela, but ophthalmitis very rare; and numbness and weakness of the lower limbs sometimes long persisted; mania and mental fatuity have seemed to follow an attack of spirillum fever. I have but few notes on changes in the urine; albumen was seldom found during the pyrexia.

Abortion in pregnant women occurs here just as in Europe and was early witnessed. The ravenous appetite has been often noted.

Even the complications (pulmonary oftenest and buboes, next hepatitis and bowel complaints) have proved to be similar to those met with in the West; and the same remark applies to the sequelæ, debility, emaciation, abscess, rheumatoid, paralytic and other nervous symptoms. Parotitis may be late or early. Other details might be furnished, but already, and from what follows, the true nature of the Bombay fever will become sufficiently evident.

Mortality.—As derived from hospital statistics, the death-rate of the Eastern epidemic will appear excessive; it has, however, varied considerably: thus in May (the worst month observed) it was 20 per cent. of admissions, but only 10·5

per cent. in September, the mean of five months being 13·7 per cent. All my notes are not yet arranged, but allowing for contingencies, I should estimate the average death-rate at 10 per cent. of those attacked; and if this ratio be applied to the mortality returns from the whole town, it will be seen that the amount of "sickness" has been immense indeed. I estimate the death-rate of ordinary fevers (malarious chiefly) seen during the period under review, at more than double; and that of severe remittents above treble, the rate of mortality just mentioned. Age and sex have not seemed to exercise much influence on this rate, but the more practical point of fatality according to stage of disease is interesting; thus, analysing between thirty and forty deaths from demonstrated spirillum fever, I find as follows:—about 50 per cent. happened within the first week or during the first paroxysm of the disease; 25 per cent. more, during the first interval succeeding; about 15 per cent. occurred during the first relapse, or in the following interval; and the remaining deaths took place at subsequent periods of a few weeks, from dysentery, parotitis, or other sequelæ. The fact that three-fourths of all deaths happen during the first paroxysm, or just afterwards, is sufficient evidence of the severity of this disease as witnessed in hospital practice, and a large proportion of sufferers owe their death directly to the fever itself. Speaking generally, the epidemic became less fatal with its gradual subsidence; but latterly there have appeared a series of fatal cases, which, in character and severity, show a tendency to the typhus-type.

Anatomical lesions.—Still of necessity confining these notes to a summary, I find no lesion (excepting that of the blood) which is absolutely peculiar to the spirillum-fever, nor is there any ordinary morbid alteration which is limited to one particular stage of the disease, or to any single organ. Some change has been noted in all the thirty-seven autopsies as yet analysed, and much the commonest was enlargement, with or without congestion, of the spleen and liver, yet how far this is due to the spirillum-disease might be questioned in India, where malaria reigns, were it not the fact that in

Europe the same thing has been found. Taking the organs of the body in succession, the alterations noted were as follows :—

Brain : in 20 autopsies congested 8 times, showing some opacity of the arachnoid 3 times, and meningeal hæmorrhage 1 ; serous effusion 2 : no evident change 4 times, including two instances of death during the first paroxysm. In a smaller series of autopsies not here included, meningeal and diffused hæmorrhages have been found : the *spinal cord* was examined and was unchanged. *Lungs* : noted as healthy 13 times in 36 autopsies, congested 10, inflamed 6, collapsed 5 times, the seat of hæmorrhage 1 : pleurisy once : the pneumonias were chiefly in the first interval of the disease, when, too, collapse of the lung was most frequent : congestion occurred during the pyrexia mostly. *Heart* : seldom diseased, though clots in the cavities, especially of the right side, or both auricles, were noted 25 times in 36 examinations ; it was fatty in aspect 4 times. *Liver* : enlarged, with or without congestion, 17 times in 37 autopsies ; regarded as fatty 3 times ; as healthy 7 times, including 4 cases dying during the first paroxysm or first interval. *Spleen* : enlarged 19 times in 37 examinations, and sometimes very considerably ; there were found fibrinous infarcts 8 times (almost exclusively in subjects dying early in the disease), and 3 examples of softening of the spleen in 15 autopsies made after death during the first paroxysm. *Kidneys* : were noted as healthy-looking 10 times, congested 9, pale 6, large 5, fatty (?) 4 times, granular (?) 1, and with infarcts 1, in all 36 autopsies. *Intestines* : 17 times healthy in 27 examinations ; small intestines congested 5 times, hæmorrhage 1 ; ulcers in the large intestine 4 times.

The post-mortem examinations conducted at the Goculdas T. Hospital, do not differ in results from the above. Frequent microscopic investigations of the principal organs were made, but my short-hand notes are as yet undeciphered ; I may remark, however, that granular and fatty degeneration (sometimes acute in character) of the hepatic and renal gland-cells was commonly found ; fatty degeneration of the

heart-muscle does not occur nearly so often, and it may be quite absent when during life the pulse was very feeble. When necropsic results are arranged according to stage of the disease, the proper plan to follow, I find, as before intimated, no invariable connection between lesion, organ and progress of illness; nor does the presence of the spirillum in the blood, or its bequeathments, inevitably entail such local changes, *e. g.* of a physical character, as might be anticipated; hence, to all appearance, death may ensue directly from the fever; but further observations are needed with reference to the dynamic, physical and chemical changes causing death.

Etiology.—The predisposing causes of the spirillum fever vary in importance; whether sex is concerned has not been made out here, yet I think the mother of a family was affected first oftener than after her children; age has no peculiar influence, the most common periods of life in my lists being from fifteen to thirty years; infants at the breast and the oldest people may suffer. In marked contrast to malarious fevers, and especially the remittent, the season of the year has not seemed to influence the progress of this new epidemic, or if an influence were exerted, it was in a precisely opposite direction. Thus, as is well known, malaria abounds least in the hot season when the soil is parched and vegetation dried up, yet it was in May that the spirillum fever reached its maximum of intensity; and, on the other hand, after the heavy rains, when malarious fevers become common and severe, the same fever had already far advanced in its uninterrupted decline and was not rekindled. As an epidemic it began in the cold weather (December to February) 1876-77, increased rapidly until June when the rains begin, and subsequently declined in a gradual manner until the close of 1877, or the date of my last notes—being then by no means extinct. In India, such facts as these are significant.

As to occupation, none is spared; immigrant labourers and their families (chiefly), weavers, cab-drivers, railway servants, petty shopkeepers, mill-hands, school-boys, domestic ser-

vants, hospital servants and attendants, students and surgeons; these and many others are in our lists. In entire accordance with this, the fever was strictly localised in the poorest and most overcrowded quarters of the town; and I am assured that very few cases, indeed, occurred amongst the better housed and better fed of the native population. The European community was virtually exempt. If these data be accurate (and I believe them to be so) the nature of the Bombay fever should be no longer doubtful; and I know of no facts contradicting the inference that we had here to deal with an epidemic essentially due to destitution and overcrowding. In making this statement I do not forget that the worst fed and housed are always the greatest sufferers from disease, including, in the tropics, malarious fevers; nor is it denied that the famine-stricken immigrants must have at least equally suffered from like maladies.

Adverting to the more immediate causes of the spirillum fever I would look for them in want and contagion, that is to say, to the conditions which alone have been found influential in Europe. One of the earliest cases I saw was that of a destitute lad who, while tramping to the Presidency town, from the famine district of Poona, was seized with fever in the upland country, and was barely able to crawl to hospital immediately on his arrival in Bombay; it was then the seventh day of the fever according to his plain story; the symptoms were typical and I found the blood to contain abundant parasitic elements; next day the usual crisis occurred, the spirillum disappeared and there was no relapse. Such instances were numerous, and they seem to show the likelihood of the spirillum fever originating *de novo* as the result of want, toil and exposure; there remains, however, the possibility of this lad and others like him having somewhere, and at some recent time, been exposed to infection whether of persons or things; and that this, or an equally potent third factor, is concerned, appears from the following narrative. A father and young son tramping from the same district up-country to Bombay, at a short interval of time afterwards, were also seized with fever on the journey

and came at once to hospital, where the symptoms proved to be quite typical of quotidian ague; the blood of both individuals was repeatedly examined without any trace of the spirillum being seen. I am aware that even precise instances of this kind have but a limited value in debate, yet they are such as are met with in practice and upon their interpretation opinion much depends.

If the originating influence of want be admitted, still it will be evident that not all, or nearly all, cases of spirillum fever can thus have arisen; and in Bombay as elsewhere almost every circumstance in the natural history of the disease, which is usually regarded as evidence of contagion, has been abundantly observed; thus, the fever rapidly became epidemic at a non-malarious season of the year, and it distinctly spread from the destitute immigrant to his family, host and neighbours, no other interpretation being possible of many instances coming before us at hospital, where nothing was more common than the admission of whole families down with this fever, whose members had been successively attacked, and their houses were not seldom found to be foci of the disease, in one instance eighteen sick persons being traced as coming from a single dwelling. Of the examples—not a few—of patients in good bodily condition suffering severely, it can only be said that in all of them there had existed the possibility—in several the extreme probability—of direct contagion; amongst such instances of spirillum fever in the well fed and fairly housed, were those occurring in the hospitals themselves amongst servants, ward attendants, and medical subordinates. The two native gentlemen and myself who undertook the task of investigating the new disease did not all escape, for Dr. Anna, M.K., had a severe attack of the fever, and I also at a later period. Lastly, it happened that several patients admitted for other ailments became, after a period of time surpassing the longest agreed upon as that of the incubation of relapsing fever, themselves attacked, and of all these it may be said that they had been exposed to contagion.

No suitable opportunity has occurred of measuring pre-

cisely the incubation period of the spirillum fever; but I have always regarded it as corresponding to the apyretic interval which separates one febrile paroxysm from the next.

There has been no evidence of the new fever arising from malaria, and there is none (that I know) of malarious fevers being due solely to want and overcrowding.

That the spread by contagion was not more glaringly apparent may be due to the influence of a tropical climate, for the cattle disease did not spread in Bombay with the celerity that it does in England.

The spirillum fever of Bombay was not communicated to rabbits and pigeons by inoculation with infected human blood or by injection of the same into the veins.

Lastly, that the greatest misery, densest overcrowding, and a high mortality prevailed for months in the low quarters of Bombay city, is known to many residents. I myself found in inspecting certain of these localities, and other official reports bear ample testimony to the fact, that by the immigration of thousands of families, starved at home and driven to seek work for food in the Presidency town, the usual influx of labourers during the cold season was augmented to such a degree, that existing dwellings (no new ones were built) became over filled, food scarce, and the death-rate from "fever" so high, as sometimes to exceed the total death-rate from all causes in previous years. The authorities were at last moved to act, and with diminished overcrowding, the epidemic began *pari passu* to subside.

Thus I should interpret our late experience, and reverting to the past, it is interesting to note that during the years 1864-5, an almost similar state of things existed in Bombay as a consequence of marvellous commercial prosperity (not famine). At that time overcrowding became excessive, and a febrile epidemic arose (it was nothing less), which by good authority was referred to the typhus type; and then as now several of the attendants and pupils at the large Native General Hospital were attacked with fever, which proved largely fatal. At this distance of time I cannot ascertain if

there then coexisted fever of the relapsing type, but that this latter is no new thing in Bombay, would appear from a cursory inquiry I have made into hospital records of late years, which show that occasionally there have appeared cases of fever amongst the poorer classes displaying the general characters of the spirillum disease, and one might ask if it be not from such sporadic examples that the idea of a relapsing remittent has been derived. It is, perhaps, as much by tradition as by observation, that here, nearly all idiopathic fevers are still attributed to the influence of a pervading miasm; but even the more conservative amongst us have had to allow that veritable enteric or typhoid fever is to be seen in Bombay, now the true famine fever has to be admitted, and I should myself add typhus to the list of great pyrexias rescued from the oblivion underlying the term "remittent fever" as commonly employed.

2. *The spirillum and other blood-elements.*—My observations were begun in April last (1877) with the microscopic examination of blood taken by means of a clean needle from the washed finger of a fever patient in the Camp of Refuge; the glasses used were carefully cleansed, and an excellent $\frac{1}{16}$ th inch immersion lens by Powell was employed: subsequent proceedings were conducted in the same manner, the blood being examined immediately on withdrawal, and afterwards if needed. Experiments were made by submitting the specimens to an elevated temperature, and all appearances seen were noted in order—blood-plasma, fibrine-bands, and rate of coagulation, red corpuscles, white globules, protoplasmic bodies, granule-cells large and small, free granules, rods or filaments, and finally the spirillum. The times of examination were 9—10 a.m., and 2—5 p.m., which correspond to the intervals between meals; and the seasons were the hot weather (April—June), the rains (June—September), October and November (when malarious fevers become common), and part of December (cold season). The subjects examined were of all nationalities and castes, no differences among them being perceptible; each patient was, as a rule, examined on admission, and on several subsequent

occasions, but from want of time I had sometimes to be content with single observations when these were of a positive character, the diagnosis being then regarded as sure, and experience invariably justified the assumption. Healthy blood was from time to time submitted to scrutiny, in order to rectify possible errors; and the sweat, saliva, secretion of blisters and sores, the urine, &c. of fever-patients were also examined at intervals. A bare summary of results can be offered in this place.

1. The blood-plasma is clear, clouded or granular. Almost invariably in the pyrexial stage, where spirilla abound, it is remarkably clear, and to the experienced eye at once characteristic: in pure remittents also it is pellucid, whilst in temporary pyrexias and symptomatic fevers it is apt to be much clouded. When free protoplasm abounds, the plasma is usually thick and even granular in aspect: it is clouded often at the beginning of the interval, *i. e.* immediately after the paroxysm, in the spirillum fever, but no absolute rule obtains in this matter. The plasma speedily separates into fibrine and serum.

2. The fibrine-bands during the pyrexia are usually very distinct, and brilliant almost as crystals; they entangle in their meshes, and so seem to stimulate, the wriggling parasite which endeavours (as it seems) to escape. The bands are thicker than the spirillum, straight and quiescent; their visibility is partly dependent on the translucency of the serum, and they have also a connection with free protoplasmic matter.

3. White globules. I do not regard the superabundance of these bodies at the close of and after the febrile paroxysm as very significant, because habitual leukæmia may be present also; and the excess is seldom marked.

4. Red corpuscles. These are clear and perfect in typical spirillum fever, and frequently their meshes become, after coagulation, the refuge of the spirillum whose movements are then imparted to the corpuscles, and so produce a twitching or twirling, which may for a time be the only sign of the presence of the parasite. Sometimes there is seen a sticking

together, as if some affinity existed between the corpuscle and spirillum; and the latter will drag about the former causing it to alter its shape; this adhesion may persist after death and is probably mechanical.

5. Granule cells and protoplasmic masses, may be numerous and prominent objects in the field; they include, A, large nucleated globular cells which may change their form, become vacuolated and undergo fatty degeneration; possibly they are derived from the spleen; B, large, flat cells, probably endothelial, from the inner membrane of artery, vein, or lymphatics; these possess a fixed contour and may also become charged with fat-granules; C, masses of protoplasm of varying size, and when large capable of assuming great variety of form; they throw out also long and slender mobile filaments, which may simulate the spirillar body. Diffused protoplasm has the form of little clumps, which are apt to aggregate in clusters of peculiar aspect.

6. Free granules are not uncommon, but probably not limited to the spirillum fever; their character is probably various, some being fatty, some albuminous, and some resisting the action of both acids and alkalies; whether or not the granules which seem to grow out into rods are perpetuating spores or germs of the parasite, is as yet undetermined.

7. Rods or filaments. Under this heading I have included various minute bodies, whose character is still uncertain; when detached they may resemble the spirillum so much as to give rise to the idea of their being an early stage of its formation, but I have sought in vain for the succeeding stages when spiral form and active motion would be imparted. They exist oftenest along with the active parasite, but in other fevers may occasionally be found; seeming to arise either from free granules or from protoplasmic extension, and in the latter case are, for a time at least, attached. A certain amount of proper movement may be noticed in them; one extremity is usually somewhat expanded and their contour may be wavy.

8. *The Spirillum (Spirochæte, Ehr.)*.—Its ordinary aspect is that of a colourless, homogeneous, and very delicate,

spirally-twisted filament, which during life is in constant motion amidst the *liquor sanguinis*; the length varies from $\frac{1}{1500}$ th inch to $\frac{1}{500}$ th inch, its breadth is immeasurably slender, or probably not more than the $\frac{1}{30000}$ th to $\frac{1}{50000}$ th inch. The spiral or cork-screw twist is regular, and best seen when the organism is quiescent or after its death, whilst during active movement (especially the lashing side movements) it becomes undone and may almost disappear, the filament meantime gaining in apparent length. The motion of the spirillum though continuous, is transiently intermittent and not constantly in the same direction; it is compounded of a rotation on the long axis—which is the most characteristic—a lateral or lashing movement, and a progression forwards or backwards; all these actions may be so rapidly performed as to puzzle the eye of the observer, who sees only swarming or shooting non-defined bodies traversing the field of the microscope. The filaments have neither head nor tail, possess a firm consistence and are highly flexible and elastic, but not contractile in the proper sense of the word; a faint yellow tinge has been noticed within them, and their visibility partly depends upon the clearness of the medium they inhabit. Not much variety in their general aspect and characters has been detected, that of dimensions being the chief. Vital movements may persist some time after death of the body (I have seen them thirty-five hours afterwards), or after removal of the blood from the living subject; they gradually cease, a brief lashing or twirl being noticed at long intervals in the midst of the countless bacteria and bacillar rods which so soon grow up, and finally the spirillum disintegrates and disappears, leaving no organic trace behind.

The number of spirillar bodies in the blood of a patient suffering from this specific fever, is simply immense, and often incalculable except by hundreds of millions; dozens may be seen in the field of the microscope at one time, troubles of the circulation being clearly enough indicated in the patient's dusky and harassed visage; on the other hand, the spirilla may be rare and to be found only after very patient

search, but it is seldom that only one is seen, and it seems probable that when present they exist in considerable numbers. Doubtless a relationship obtains between the abundance of the parasite and the intensity of the fever, but it is a contingent one; for I have observed the spirillum to be tolerably numerous during collapse (temp. 95° , F.), and at ordinary temperatures, while a rise in heat when considerable (105° to 106°) may be attended with a positive diminution in the numbers of the organisms, and is consistent with their entire disappearance. Commonly, however, pyrexia and parasite are in closest relationship, at particular times; but I have failed to verify some of the rules laid down as regulating such connection. In Bombay a rise of temperature (without complication) initiating either first paroxysm or true relapse is not invariably preceded by the appearance of the parasite in the blood, and in the rise pertaining to pseudo relapses, the spirillum will not be found at all; it is also absent during the fever symptomatic of local complication, and its advent during a continuous high temperature may be held correctly to indicate the supervention of a specific attack, which will pursue its course independently of attendant conditions. Lastly, I have met with the parasite at periodic dates, when there was absolutely no rise of temperature. Amongst the variations noted by us that of aggregation of the spirilla is prominent. I believe this may occur during life, difficult as it is to conceive how the circulation can be properly carried on while the blood contains masses much exceeding the diameter of most capillaries, and sometimes enveloping protoplasm or red corpuscles themselves. In short, the idea is inevitable that we may see here the foundation of a physical pathology, so striking are the appearances noted. The activity of the spirilla in these dense clusters is sometimes so great, as to impart a resemblance of swarming zooglœa or micrococcus colonies; and to give rise to the impression that the groups may have originated from separate centres.

A less prominent aspect is that of filaments joined together at one end or at one part of their length, whence

result many varieties of form. When adherent at one end, two or more filaments may extend almost or quite across the field, forming long vibrating threads, like the wires of a telegraph, stretching in different directions; and such threads abruptly parting, simulate multiplication by fission.

The spirilla do not always thus cluster or adhere, but they have a natural tendency to seek a liquid medium and so collect in the pools of serum left after coagulation of the blood, where they may often be found when in the solid parts, or clot, they are invisible; hence in doubtful cases, it is well to re-examine a given specimen of blood after an interval of a few hours.

Of the natural history of this remarkable parasite nothing new has been learned in Bombay. I have, indeed, ascertained, by repeated examinations, that the contents of the *thoracic duct* are always free from contamination, at times when the blood swarms with the spirillum; so that one might be led to infer the germs or spores of the organism do not enter the blood *via* the food or digestive canal. Such microscopic scrutiny as is practicable of the solid viscera—lungs, spleen, liver—has led to no serviceable illumination as to the source or lair of the spirillum, nor have my examinations of the blood in different localities—*e. g.* right and left side of the heart, portal and hepatic vein, splenic artery and vein—as yet led to certain results. With me, as with others, attempts to cultivate the parasite have failed; thus blood containing spirilla taken during pyrexia, and specimens taken both before and afterwards, have been kept at fever heat for hours without any notable change appearing; a very high temperature (110° F.) probably hastening the death of these organisms. It seems to me highly probable that the spirillum is developed in the blood itself, yet if this be so, it is strange that no intermediate stage of development or growth has been satisfactorily made out in the course of many hundred blood examinations. We have learned, indeed, that the bacterium may appear and disappear within the interval of a very few hours, and that its continuance during an entire febrile paroxysm of several days

duration, is most probably effected by successive generations, but whence these latter come and how they are developed are questions I own myself unable to answer.

The influence of such reagents as water, common salt and quinine in solutions of varying strength, upon the spirillum outside the body, was inquired into; and from our brief experiments it seemed that soluble quinine, much diluted, had the effect of decidedly bringing the movements of the parasites to a standstill.

As to the identity of the blood spirillum with similar filaments to be found in the saliva of fever patients, it might be difficult from appearances only to disprove this; yet I note that the spirillum (spirochæte) of the saliva is present in the apyretic interval, and, even during the pyrexia, does not vary in numbers at the same time with the blood spirillum. Further, my own saliva contained the same filaments when I was conducting these inquiries, and was in good health, excepting occasional indisposition from ordinary feverishness.

The sputum is indeed excellent breeding ground for the lower organisms, and so may the blood itself be, for in one of my fever cases, six and a half hours after death, it was found to swarm with long and mobile bacillar (?) filaments, &c.

Regarding other identifications which could throw light upon the source of the blood spirillum, my note book shows that in a tank at Bombay resorted to for drinking and washing purposes by the friends of two children who were attacked with the spirillum fever, there existed both before and after the rains, an active filamentary body which, on comparison with his plates, appeared to be Ehrenberg's *spirochæte plicatilis*. Rather contrary to my anticipation, its dimensions were so much in excess of those of the blood spirillum, that I cannot suppose the species to be the same, and we have no evidence that the spirillum fever is due to contaminated water supply.

DESCRIPTION OF PLATES XVII AND XVIII.

The Spirillum of Recurrent Fever. (Vandyke Carter, M.D.)

PLATE XVII.

- FIG. *. Spirillum in motion.
a—n. Spirillum of the blood.
o, p. Spirillum of saliva.
q, r, s. Filaments seen in ague, &c., in the blood.
t—z. Protoplasm endothelium filaments in the blood during life.

PLATE XVIII.

- FIGS. 1—5. Protoplasm endothelium filaments in the blood during life.
6—10. Rods, &c., in blood after death.
11, 12. Spirochæte bacillus from water of tanks.