OBSERVATIONS ON SPIROCHAETA EURYGYRATA, AS FOUND IN HUMAN FAECES.

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Introduction.

RECENTLY attention has been directed to the Protozoa and allied Protista occurring in the faeces of soldiers who had contracted various forms of dysentery or diarrhoea in Gallipoli or Flanders. A few papers recording the results of such observations have been published, but no mention has been made, so far as I am aware, of the occurrence of spirochaetes in the faeces of such patients, except by Fantham and Porter in 1915. Similar spirochaetes may occur in the motions of apparently healthy persons. Frequently the stools of dysenteric patients found to contain the organisms were fluid and rather foul-smelling. Apparently the pathogenicity of such spirochaetes is slight, but they seem able to flourish and multiply in dysenteric intestines.

Material and Methods.

The material, as already indicated, was chiefly obtained from the stools of dysenteric patients during 1915-16. The stools of a few normal persons were also examined. When dealing with large numbers of stools in a somewhat limited time, as has been necessary on many occasions, the organisms were observed in fresh preparations, between coverslip and slide, with the aid of $\frac{1}{8}$ in. or $\frac{1}{4}$ in. objective and Huyghenian ocular 3. Twenty-three cases of single infection with spirochaetes were detected by this means alone in three months. However, the spirochaetes are seen to be more numerous in a preparation, and to occur more frequently in stools, if dark-ground illumination is used. Also, if stained smears of stools are made, many more infections will be found, perhaps even as high as 50 per cent. of the cases examined.

The organisms may be fixed wet in osmic vapour, hardened in absolute alcohol, and stained with gentian violet, iron-haematein, haematoxylin, thionin, and the various modifications of the Romanowsky stain. Bouin's fluid and corrosive acetic alcohol may also be used as fixatives, while dry smears may quite well be used for rapid diagnosis.

Movements.

The spirochaetes observed in faeces move quickly, and their bodies exhibit great flexibility. As I have previously pointed out (1907, 1908), the movements may be divided into two components—an undulatory flexion of the body, mainly for progression, and a corkscrew or helicoid movement of the body as a whole, due to its coiling. The number of waves along the body of a spirochaete varies according to the rate of progression of the organism, and is an index of its rate of motion, being also slightly influenced by its thickness. The coil of the helix of a rapidly moving spirochaete is much closer than that of a slowly moving organism. In other words, the body of a rapidly moving spirochaete is thrown into many small waves, while slowly moving forms are thrown into fewer, larger waves, as I have shown in my work on *S. brachialis*. If a single living specimen be watched for a sufficiently long time under the microscope to allow of it changing its rate of motion, the change in the character of the coils can be observed. Reversal of direction of movement is common. Either end of a spirochaete can be forwardly directed, and the organism can easily return on its path. Corkscrew, boring movements also have been observed, and Catherine-wheel-like motions have been seen.

Agglomeration of the gut spirochaetes is common, tufts or tangles being produced. In my experience, such agglomerations or tomenta are more common in fluid stools than in semi-formed ones or those of normal consistency. The individual members of a cluster can easily separate from or rejoin the group.

On some occasions when shed epithelial cells from the intestinal wall have been present, spirochaetes have been seen to penetrate the cells. After a relatively short time they usually became quiescent there, and sometimes produced their resting coccoid bodies. Occasionally the spirochaetes might be seen to emerge again from the cell.

While usually the movements of the spirochaetes are very graceful and are undulatory and corkscrew in character, very rarely jerky or boomerang movements have been observed. These latter are perhaps more obvious in some of the shorter spirochaetes.

Morphology.

The spirochaetes of faeces are best termed *S. eurygyrata*, as will be shown in a subsequent section. They have markedly flexible, sinuous bodies, and, when observed in numbers, present morphological variation. The bodies of the organisms show a series of curves or waves, the exact number of which depends chiefly on the rate of motion prevailing at the time the spirochaetes are fixed or observed. The number of curves or waves may be as small as two or as great as nine. Bowed and coiled forms may also be seen. The ends of the organism vary somewhat, according to the stage of growth or the recentness of division. Usually they are tapering. (See text figure.) Some may be rather more rounded, while others have quite pointed ends. A few spirochaetes with one end more pointed than the other have also been seen, the appearance resulting from the extending attenuation at a recent division. Similar morphological variation in *S. balbianii* was described and explained by me in 1909. Internally, a diffuse nucleus consisting of chromatin rodlets or granules can be observed in well-stained specimens from stools, or in living forms examined by the aid of the parabolid condenser. In the latter case, the chromatin granules appear as minute refractile spots. However, it is not always easy to see the granules.

The cytoplasm of the spirochaetes is almost homogeneous and is non-vacuolated. The presence of the chromatin granules or rodlets at intervals down the body gives rise in clear specimens to the alveolar or chambered appearance mentioned by some workers in connexion with the larger spirochaetes found in molluscs.

In some spirochaetes the perioplast is seen to be laterally extended in the form of a very slight sinuous membrane or crest, which is only observed with great difficulty, as it is often contracted against the body.

By measuring a number of spirochaetes obtained from various patients on different days, the variation in length was found to be from 3μ to 15μ , and the breadth was about 0.25μ or less. The breadth, however, is not easily determined, but some forms are clearly stouter than others. Multiplication by binary fission has been observed in the living organisms and forms undergoing similar division have been seen in stained preparations.

The formation of coccoid bodies or granules in the gut spirochaetes has been studied in fresh preparations by both ordinary illumination and sometimes by the use of the parabolid condenser. The cytoplasm concentrates around the chromatin rodlets and the concentrations gradually become oval. The coccoid bodies thus formed are set at liberty, either by ruptures in or disintegration of the parental sheath. The elongation of coccoid bodies, their assumption of the spirochaetiform facies and their emergence from groups of such bodies have all been observed in life.

The spirochaetes as such may disappear from the stools of a patient and then after some days reappear again, and thus there is variation in numbers from day to day. The more fluid the stool the greater is the number of spirochaetes present as a rule. During the period when the spirochaetes as such are absent from the stools, it is probable that they have produced granules or coccoid bodies. Owing to the large amount of finely divided debris present in the intestinal contents, it is not yet considered practicable to differentiate spirochaetal granules from other minute particles in stools. In my opinion, granules cannot be considered, at present, to be definitely spirochaetal in origin unless their formation from and subsequent elongation and development into spirochaetes have been observed in the living organisms.

A large number of drawings of the spirochaetes found in human stools have been prepared, and it is hoped that

Spirochaeta eurygyrata,
morphological variation.
 $\times 1,400$.

it will be possible to publish them later, when the morphological variation exhibited by these organisms will be more fully shown than is possible in the text figure.

Earlier Observations.

There are a few vague references in the literature to spirochaetes, or spirilla, as they were often called, in human faeces. Thus, H. Kowalski (1893, 1894) recorded the presence of spirilla in cholera motions examined by him. Apparently no illustrations or dimensions of the organisms were published, and at first they were not named. The number of curves, "about one, two, or three, seldom four, five, or many," is noted. Kowalski's first observations, made on eleven cases, are recorded in an incomplete form in the report of a meeting of a medical society in Vienna in December, 1893. During the discussion thereon Paltauf stated that Escherich in 1884 had seen spirochaetes in normal human faeces. Escherich himself in 1894 referred to his previous work in 1884-86, and stated that he had found spirilla in diarrhoeic stools of babies and adults and in cats. He compared them with dental spirochaetes, but found them to be shorter. Abel (1894) and Aufrecht (1894) also recorded the finding of spirochaetes in the faeces of a few cholera patients, the latter worker comparing them with blood spirochaetes. Rechtsamer (1894) mentioned the finding of spirilla in the dejecta of cholera patients in Caucasia.

Lustig and de Giaksa, writing in 1894, refer to their earlier work in 1886 on the stools of four cholera cases in Trieste, in which the occurrence of spirilla was noted. In their earlier paper (1886) these authors give drawings of a few spirilla, but neither state the dimensions of the organisms nor name them. On examining their illustrations I find that the spirilla measure up to 13μ . As a result of a discussion of the work of Lustig and de Giaksa, Kowalski (1894) named his organisms *Spirillum hachaiiae* or *S. hachaiicum*. However, as no dimensions and no detailed differential characters were given, either by Kowalski or the other earlier workers—most of whom called the organisms spirilla or spirochaetes indifferently, though the parasites are not stated to have had flagella, characteristic of spirilla—it is very doubtful whether Kowalski's names are valid.

"Spirillar" or spirochaetal dysentery has been briefly recorded by Le Dantec (1903). The patient, who came under observation in the neighbourhood of Bordeaux, had been known to the author for some time, and had been at Tonkin eighteen months before, when in the French Colonial Medical Service. It was stated that the patient developed dysentery in Bordeaux. Spirochaetes were found to be abundant in the mucus of the stools. Some of the organisms showed three curves, and were 6μ to 14μ long. Coiled-up and bowed forms were also seen. Some spirochaetes were observed to enter and emerge from intestinal cells.

Werner (1909) found spirochaetes in his own stools while apparently in good health, though he had suffered from diarrhoea when in German South-West Africa in 1905. A few other cases are also mentioned by him, among them the occurrence of spirochaetes in a case of sprue. Werner separated two species of spirochaetes, which he considered to be distinct. He named these *Spirochaeta eurygyrata*, "a wide wound form," varying in length from 4.6μ to 7.3μ ; and *S. stenogyrata*, "a narrow wound form," varying in length from 3.5μ to 6.1μ . Only six indistinct microphotographs illustrate the paper, and they hardly justify Werner's statements.

Werner differentiated partly on the character of the "windings." As I (1915) have previously pointed out, the number of windings or curves is not of specific value, but is chiefly an indication of the rate of movement. Further, the processes of growth and division will easily explain the so-called differences in morphology and size between Werner's species. Morphological and biological variations appear to have been overlooked in the desire for the creation of new species.

In 1914 J. G. and D. Thomson recorded the presence of spirochaetes in the stools of healthy individuals, of patients suffering from rheumatoid arthritis, of a case of profound anaemia, and of a case of amoebic dysentery. They also found what they considered to be *Treponemata* in human stools. Macfie (1915) found spirochaetes in the stools of a monkey suffering from amoebic dysentery in West Africa, and in those of diarrhoeic patients in Accra.

Nomenclature.

From the foregoing remarks it will be seen that the nomenclature of the spirochaetes found in human stools is in a very confused state, owing to lack of precision and detail in the incomplete descriptions published. As already indicated, the species *S. hachaiiae* is insufficiently defined, and its name appears to be invalid.

It is probable that the earlier authors, and, indeed, all those mentioned in this paper, were dealing with the same spirochaete, which exhibited morphological variation due to the processes of growth and division. The first name proposed by Werner—namely, *S. eurygyrata*—will then be valid. It is therefore necessary to amend the definition of the organism as follows: *Spirochaeta eurygyrata* has tapering ends, measures up to 15μ long, and is about 0.25μ broad. It contains a diffuse nucleus consisting of chromatinic granules. The number of coils or waves is variable, depending on the rate of movement and thickness of the organism.

Conclusions.

Spirochaeta eurygyrata, Werner emend. Fantham, may occur in the stools of dysenteric and apparently healthy persons. The organism, which has pointed ends, measures from 3μ to 15μ in length by about 0.25μ in breadth.

The so-called spirilla, mentioned by some of the earlier workers as occurring occasionally in cholera motions, are included under the name *Spirochaeta eurygyrata*.

The number of coils in a spirochaete is not a specific character but is variable, and is primarily an index of its rate of motion, being also partly dependent on the thickness of the organism.

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PERFORATING AND PENETRATING WOUNDS OF THE CHEST WITH SEVERE HAEMORRHAGE:

A SUGGESTION FOR TREATMENT.

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I HAVE been impressed with the impotency of treatment for severe haemorrhage in these cases, and have recently had an opportunity of trying a method which I have not seen advocated elsewhere, and I offer it for consideration and trial by surgeons near the front. The severer cases