patient may arch the back forwards and render it difficult to hit the interval between the two vertebrae; further, these large trocars do not penetrate the softer structures so readily as the small ones, and hence may fail to perforate the theca itself; the trocar then lies between the ligamentum subflavum and the theca.

It is quite open to discussion whether trocar and cannula or an exploring needle with its stilette is the better instrument for the purpose. One is often struck with the fact that the softer tissues seem to cling to the cannula, taking a good deal of force to push it into the tissues and to pull it out again. This objection does not seem to be so marked with the exploring needle. In either case it is advisable to lubricate the instrument with a little sterilized glycerine or oil. I lay stress upon these points because some persons when ill feel even a small prick very intensely, and the pain seems to last after the cannula is at rest; and therefore it is most important to employ a method which gives a minimum of pain, although the latter may be only of momentary duration. Freezing the skin of the back has the objection of hardening the skin, so that a great deal of force may be necessary to penetrate it, and this is felt by the patient.

If it is contemplated to inject one dose only, a simple trocar and cannula or exploring needle is all that is required. It would not be difficult to protect the part sticking out from the skin, so that it is not pressed upon during the time the patient is on the operating table. It is the terminal portion inside the spinal canal that might cause damage if there were unusual movement on the part of the patient or any extensive movements like that for artificial respiration should be necessary. To meet this difficulty I have designed a cannula which would be flexible, and its end would be rounded off so that no damage would be done in a sharp edge coming against any nerve or vessel in the theca. I think it will be possible to leave the flexible cannula in position. This, however, is an aspect of the question that further experience alone can decide.

The syringe used has to meet two requirements. It must be, of course, easily sterilized; secondly, it must be of sufficient capacity to hold at least 3 to 4 c.cm. of the solution. It is necessary to have one of this size at least, for the following reason: when the cannula is in position and the fluid escaping the pressure is generally sufficient to force back the piston and so to dilute the stovaine with the cerebro-spinal fluid before the former is injected. As the cerebro-spinal fluid approaches in quantity that of the solution a turbidity appears. The piston is then pushed gently along until all the solution has passed through the cannula into the spinal canal. The graduated syringes with the glass piston have the advantage that the cohesion of the two glass surfaces is slight enough to allow the cerebro-spinal pressure to push back the piston. I do not myself think that this piston needs to be pushed back necessarily by the cerebro-spinal fluid, providing the operator gently pulls the piston back himself, taking care that the cerebro-spinal fluid is not sucked in forcibly. These glass syringes are easily broken and rather expensive. It is unwise to insert the glass nozzle into the cannula direct, because there is a great tendency for it to break. I have had made some small rubber nozzles which at one end are funnel-shaped, so that they can fit on to the glass nozzle of the syringe. The other end is made to fit on to the cannula. In this way the glass syringe is much more easily handled, and the risk of chipping the glass nozzle is avoided. Further, this rubber tube is easily detached from the syringe and then clipped so that the cerebro-spinal fluid is prevented from escaping.

DANGERS AND COMPLICATIONS.

Sonnenberg[5] reports a case in which the patient died a few days afterwards, and purulent cerebro-spinal meningitis was present. As the patient was suffering from general pyaemia, the relation of the stovaine anaesthesia to the meningitis may not have been direct. In many cases patients have a little headache coming on as soon as the operation is finished, but this generally disappears in a few hours. It would be very surprising if this form of anaesthesia had no drawbacks, and if there were no mortality that could be attributed directly to the method of the administration of the drug, or to the drug itself. It seems, however, definitely proved that whatever the dangers may be, the mortality is by no means so large as with the general anaesthetics.

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ON THE SPIROCHAETA PALLIDA AND ITS VARIATIONS.

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IN the BRITISH MEDICAL JOURNAL of February 3rd of this year there appeared a preliminary note regarding the *Spirochaeta pallida* and the *Cytorrhyctes luis* (Siegel); the views there expressed are stated in full in this paper. Altogether over fifty syphilitics have been examined. In most of them the sore, the secondaries, the glands, and the blood were examined by making from four to ten film preparations. Each set was examined by various methods, stains, etc., but generally it was found that the method of fixation or the stain employed did not make any difference, as where spirochaetes were present they were demonstrable by all the methods. Forty of the series were females, and in them the positive results regarding the *Spirochaeta pallida* were comparatively few (eight positive), while in all the cases examined the smaller bodies about to be described, and similar to those described by Siegel, were found. Two glands were dissected out, and numerous films examined, without finding a single spirochaete, while the smaller bodies were found readily. In one instance the *Spirochaeta pallida*, along with the smaller bodies, was recovered from the urine, being found in the smear from the centrifugalized deposit.

The failure to find the *Spirochaeta pallida* in every case was not due to defective technique, because where the organism was found at all it was found deeply stained enough to be readily seen. In any case the *Spirochaeta pallida* is not found in numbers commensurate to the severity of the lesion. Attention has been drawn to this feature of the matter by various workers, and leads one to infer that it is not present always or equally susceptible to stain. There can be no doubt that this organism stains more readily at one time than another, but even taking this into account, its small representation in the lesion suggests another explanation for the severity of the trouble. In a film populated by every imaginable organism it is hardly reasonable to take the scarcest though one of the most striking organisms present and label it specific. It may be taken for granted that: (1) Syphilis is caused by an organism; (2) the organism, whatever be its nature, exists as such in all the primary and secondary lesions in vast quantity; instances of the subtility and power of the contagion must recur to everyone, whilst the scarcity of the *S. pallida* makes one pause in accepting it as the only or real cause of the disease.

The difficulty in demonstrating an organism may be due to (*a*) its disinclination to take up stain, (*b*) its excessive minuteness; to its presence in the lesions varying (*c*) in numbers or (*d*) in form.

Staining.

There can be no doubt that the *Spirochaeta pallida* is difficult to stain and requires special methods. This having been recognized, there is now no difficulty in getting the organism to take up the requisite amount of dye to render its presence visible. Further, it is probable that the staining capacity of *S. pallida* varies. This may be due, at least in part, to the nature of the medium in which it lies. If the fluid is highly albuminous, the medium becomes fogged before the organism stains.

With other workers gentian violet has given satisfactory results, and in my own preparations I have used it with perfect success. Unfortunately, however, the stain fades. The first stain was a very old saturated solution of

gentian violet in methylated spirit with water and glycerine; it was allowed to act for three hours and the resulting staining was perfect. New staining fluid made up in this way tended to precipitate, but if kept warm on the film the precipitation is less prone to occur. I now use with the best results one part of a saturated solution of gentian violet (Grübler) in acetone, added to three parts of water; the stain is filtered before use. The coverglass preparation is placed in the fluid, with or without previous fixation by heat or alcohol, and kept warm in it for three or four hours; without heating, staining may go on overnight. The staining is best carried out in a covered capsule, but if left open a drop of oil on the fluid prevents evaporation. *Spirochaeta pallida* is deeply stained, and can be easily picked out from the other elements; the *S. refringens* is stained almost black. The addition of the acetone has, in my experience, given results superior to either aniline oil or carbolic acid water.

Giemsa's solution (Grübler) used in strength of 1 in 10, or sometimes stronger, and filtered (without filtering the stain is better, but deposits more quickly) with one drop of glycerine added for every ten of the stain, does well to reveal the spirochaetes, but the stain is prone to precipitate. Staining is carried out for one hour, occasionally for three. From time to time the specimen is taken from the stain, and viewed, mounted in water to ascertain if spirochaetes are visible, and if precipitation is occurring. New stain may then be applied for longer than one hour. As a rule the staining is insufficient for high-power photography. Should deposition of stain be observed, the preparation is washed in absolute alcohol, and the film may be restained in Giemsa or be placed in the gentian-violet acetone solution for two or three hours. The staining first with the Giemsa, besides revealing the presence of the spirochaetes, diminishes also the tendency of the gentian violet to stain diffusely, and the very best results are got by this method. In such circumstances *S. pallida* comes out very dark, and can be readily photographed. The actual tint of *S. pallida* and *S. refringens* with Giemsa's stain depends greatly on the degree of concentration and on whether the diluted stain has been filtered or not. (Sometimes *S. refringens* stains pink, sometimes blue or dark purple.)

Fuchsin saturated in glycerine with ½ per cent. acetic acid added, and the acidity reduced by the addition of ammonia drop by drop till the acetic odour has almost gone, acts well if the film is heated. The preparation may be stained for two days, and the staining is very clean; the disadvantage is the length of time required, and the red colour is also not so suitable for the purpose of photography. It is an excellent method for showing the small bodies in the red cells. By these methods very perfectly stained preparations of *Spirochaeta pallida*, etc., can be got, and the technique is of the simplest; but the observer must rest satisfied with few organisms and have a clear field. Any organism more difficult to stain than the *Spirochaeta pallida* may not be rendered visible by such stains, but these, if left to act for longer periods, stain the albuminous medium, so if elusive organisms exist a new stain will require to be invented to render them visible. Besides the *Spirochaeta pallida*, there are numerous other objects seen, and it is among these that the explanation may be looked for to account for syphilitic manifestations without the *Spirochaeta pallida*.

The Minuteness of the Organism.

In a deeply-stained film from a chancre there are crowds of minute particles which might be anything, but occasionally one imagines a resemblance to larger and more definite formations. It is certainly within the bounds of possibility that the organism of syphilis is extremely minute in at least one phase of its life-history. Fig. I shows the minute dots from a ruptured white cell which are not stain, but which might be merely protoplasmic granules from the cell. They are nevertheless not unlike Leishman-Donovan bodies. The difficulty of staining these organisms (if they are such) within the cell is self-evident; when the spirochaetes are visible the cells are usually opaque. The precipitation of Giemsa's stain renders it useless in most cases for the identification of these minute bodies. Against the possibility that the organism is very minute is the fact that coarse filtering removes the contagion from syphilitic juice.

Organism Absent, if Scanty.

The general trend of opinion is that the *pallida* varies in numbers, but is never entirely absent from the lesions, and, when found, it stains readily. Herxheimer[1] has shown that the *Spirochaeta pallida* is most numerous at night. Is this a possible explanation of the nocturnal exacerbations in this disease? The fact that *Spirochaeta pallida* may only appear in one corner of a film and be found in no other part of the field points more to the scarcity than to the invisibility of the organism. The comparative scarcity or entire absence of *Spirochaeta pallida* from obviously syphilitic sores almost necessarily precludes this germ from being the sole infective agent. In every case I have examined with a generalized syphilitic rash the *Spirochaeta pallida* has been absent from innumerable film preparations. I have therefore come to the conclusion that the rash could not be caused by *Spirochaeta pallida*, more especially as the smaller and more numerous forms were invariably present in vast numbers. I have been more successful in finding *Spirochaeta pallida* after mercury had been administered. It may be possible that it is the form the organism takes when a struggle for its existence begins.

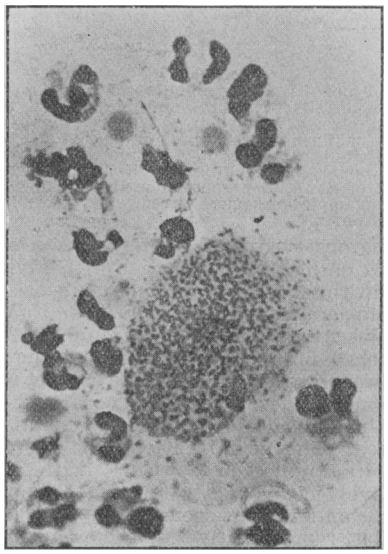

Fig. I.—Photomicrograph (×900) taken by Dr. Leslie Buchanan from preparation from vulvar sore, stained with Giemsa. Distended pus cell ruptured, freeing small bodies.

Variations in Form.

As Rille[2] has pointed out, this spirochaete had been seen years ago, but its significance had not been appreciated. Similarly the other types to be presently referred to have been passed over as being contaminations, artefacts, etc. In the films from chancres, especially in females, the sores are usually so foul that the films are apt to be one continuous layer of pus cells, fungi, and bacteria of all descriptions; when the sores are cleaned and infective serum expressed, no spirochaetes are visible, so where the staining is intense we must be looking at the other type of infective agent without recognizing it. From the first, when going over the slides in detail—and on some many hours have been spent—I tried to account for every particle seen, labelling it as precipitated stain, dust, coccus, bacillus, spirochaete, etc., and in this way I began to perceive some kind of resemblance between the apparently indiscriminate collection seen in preparations from syphilitic sores, etc.

It seems, therefore, to me that among so many visible organisms quite capable of taking up stain one causing syphilis may be looked for, and especially so when it is remembered that filtering removes the infective element from the juice of syphilitic lesions. It has also been shown that material capable of infecting monkeys has been found to be free from spirochaetes.[3] It would therefore appear that there must be another pathogenic agent hitherto not recognized, unless it be the *Cytorrhyctes luis* or bodies similar to it capable of transmitting the disease. The prevalence of other forms found more or less constantly in my slides, and sometimes in countless numbers, has led me to infer that the spirochaetes were merely

stages in the development of an organism which in all probability is the cause of syphilis. In some cases the purulent discharge from the uncleaned sore is almost solid with the small bodies about to be described. The most prevalent form which I have found in connexion with syphilis is more like the Leishman-Denovan body than the *Cytorrhytces luis*. Lately it has been shown by Dutton that these bodies in certain circumstances develop tails, and this exactly coincides with one phase of the organism I have found.

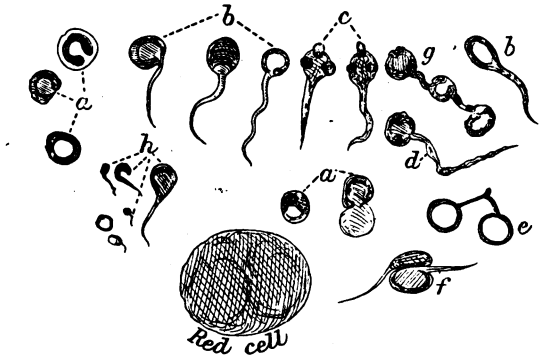

Fig. II.—*a*, Types of the ring and horseshoe bodies; *b*, the same with addition of tails; *c*, type found more or less universally, glands, blood, etc.; *d*, form showing the formation of a daughter body; *e*, unusual form indicating fusion or fission; *f*, commoner configuration indicating fusion of fission (probably the latter); *g*, chain of bodies approaching to spirochaete form, a further development of *d*; *h*, apparent uncurling of horseshoe body with minute examples of same. A red cell is drawn in about the same proportion.

It is to be observed that where syphilis is contracted from a more or less pure infection with trivial primary lesion, while the common micro-organisms, *Spirochaeta refringens*, etc., are absent, the *Spirochaeta pallida* and the smaller bodies are present in larger numbers.

When such a pure infection is found the *Spirochaeta pallida* is always associated with the smaller forms which I affirm are merely developmental stages, and it is just in such cases that the development of the organism can best be discovered. The magnification I have employed has been $\frac{1}{12}$ Leitz immersion objective, with a No. 10 or 12 Watson eyepiece. The development of the *Spirochaeta pallida* from smaller forms seems to me to be as follows:

The smallest representatives of the organism capable of any delineation and of definite character are small spheres of protoplasm containing a horseshoe-shaped more deeply-stained part.

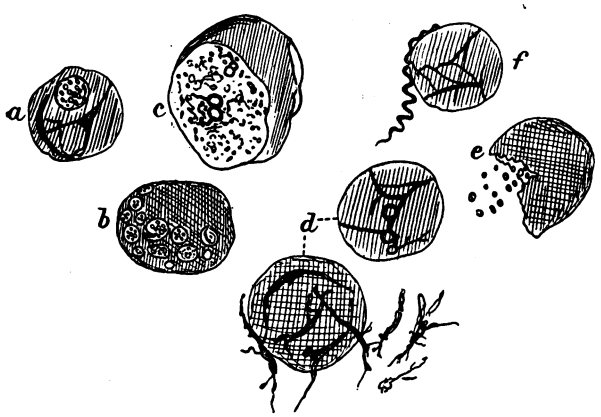

Fig. III, 1.—Diagram of red corpuscles containing small bodies: *a*, cell showing small collection of bodies in one set; *b*, cell with numerous collections; *c*, drawing of cell shown in Fig. III. 2; *d*, cell showing wrinkles (probably) also ditto of albuminous field; in some the appearances indicate bodies like those shown in Fig. II; *e*, burst cell disseminating small bodies; *f*, cell with *Spirochaeta pallida* closely applied.

The deeper stained part may be all that is visible. In every film where the *Spirochaeta pallida* has been observed numerous examples of this type were also present. To photograph such small and faintly-stained bodies has been found almost impossible, so a diagram (Fig. II) will have to suffice. With Giemsa's solution these bodies stain a lighter shade of the same colour as the nuclei. The next stage in the development of the organism shows these little bodies with tails. They are drawn (Fig. II, *b*) from a film made from serum obtained by a hypodermic needle from a groin gland in an early case of syphilis in a female; the films taken from the sores showed bodies similar to the first type. The head in some cases is clear; in others (see Fig. II, *c*) clear with dots at the sides, and in some a dot opposite the tail; in others the whole head is solid or mostly solid, but clearer towards the tail. In some fields the ring-shaped bodies were to be seen as if unfurling

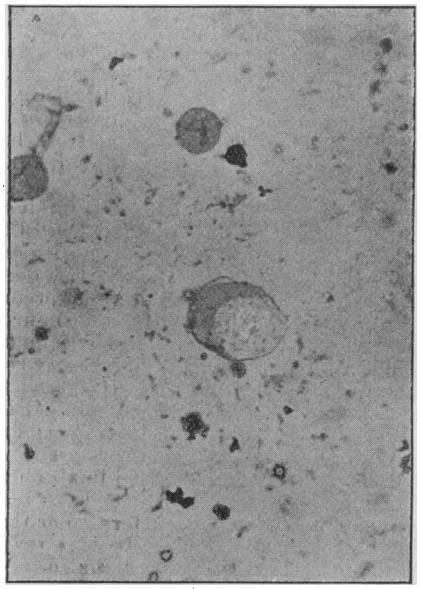

Fig. III, 2.—Photomicrograph, × 900, taken by Dr. Buchanan from smear from small, cleaned, primary sore. Stained with gentian violet. Shows a red corpuscle distended by small bodies, some similar to those shown in Fig. II, *c*. Intermediate stages between normal cell and such a one or one ruptured were visible on the same film. Note also the numerous dots (some tailed) in the same field, identical with those contained in the red cell.

to form comma-shaped particles (see Fig. II, *h*). In the largest specimens the tails were very readily made out to have a double twist. Similar bodies to these, but without the tail, have been noted in some red corpuscles, and also in some leucocytes in the films from vulvar sores, or from the primary sore on the penis (see Fig. III, 1 and 2, and Fig. I). Occasionally in the multinuclear leucocytes stained with Giemsa's solution are to be seen spherical blue bodies about the same size as these. These tailed bodies were found invariably in films made from the sores, glands, secondaries, and the blood in four instances. They were also seen motile in the fresh unstained smear from the sores and from the dissected glands. At other times two tailed bodies are to be seen as if fusing, or it may be

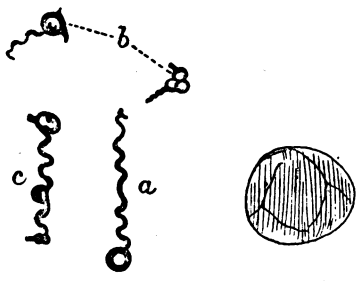

Fig. IV, 1.—Diagram from same film as Fig. III, 2. Shows (*a*) typica *S. pallida* arising abruptly from ring body with peg thicker than *S. pallida*. Above are seen types (*b*) intermediate between it and those shown in Fig. II. Besides it (*c*) another figure of *S. pallida* showing the ring body with the peg, but the spirochaete attached to the dot at the side.

dividing (see Fig. II, *f*); sometimes it is a hollow sphere with a dark body or two hollow ones which are together. An example of the hollow ring similar to the hollow sphere type is to be seen lying close to the spirochaete shown in Fig. VI; it has doubtless become detached from another spirochaete. As the commonest type, the ring with the peg is the most easily found. The dark dots on the sides of these bodies may develop into separate bodies by acquisition of a tail. Every stage between these tailed bodies and the spirochaetes can be made out. A drawing

and two photographs are reproduced to illustrate this point (Fig. IV, 1, 2, 3); *a* shows a typical *Spirochaeta pallida* with a well-marked head and a thick peg from which the ordinary spirochaete conformation abruptly springs. Other spirochaetes with more solid heads are to be made out also. Below the *Spirochaeta pallida* shown in Fig. IV, 2, is to be found a typical small body with a tail and a dot opposite the tail. It was the heads of

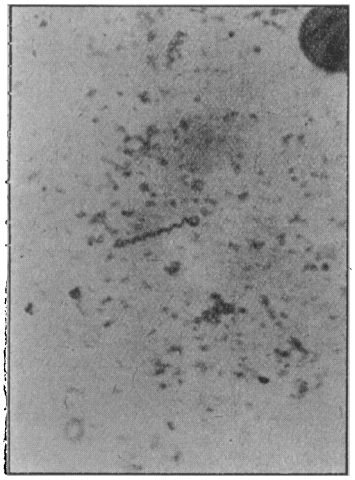

Fig. IV, 2.—Photomicrograph (× 1800), taken by Dr. Buchanan, of spirochaete drawn in Fig. IV, 1, *a*, and smaller bodies, Fig. IV, 1, *b*.

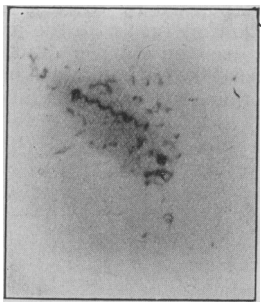

Fig. IV, 3.—Photomicrograph (× 1800), taken by Dr. Buchanan, of spirochaete drawn in Fig. IV, 1, *c*.

these two organisms, which made me recognize the others less definite when unattached. The head in this spirochaete is not a curl of the filament, but a distinct formation. Numerous illustrations of this type have been published.

The less mature bodies are vastly more numerous than the more striking spirochaetes, and it seems to be a hasty or premature deduction to label the more conspicuous but scarcer spirochaetes as the specific organisms. These smaller bodies I have found in the general circulation; in one instance in vast numbers; on several occasions there was a well-marked haematogenous jaundice; the woman died in the poorhouse, and no *post-mortem* examination was allowed. Syphilis is occasionally so

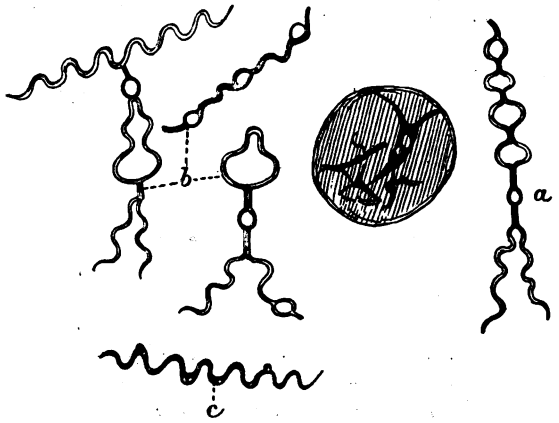

Fig. V.—Diagram of types of spirochaetes (*a*) indicating longitudinal division and also (*b*) formation of round bodies (a combined method); (*c*) *Spirochaeta pallida* with dots or thickenings which tend to become hollow. A red cell for comparison in size.

acute as to be the cause of death, the cases being mistaken for typhus fever. Since the spirochaete has been demonstrated certain dark dots have been described which investigators have tended to regard[1] as due to precipitated stain; I am certain, however, that this explanation is not correct. Where the spirochaetes are most numerous the dotted specimens are frequently found, and in my opinion are not precipitated stain, but excrescences on *Spirochaeta pallida*, and part of the process of reproduction. These dots usually rest on the crests of the waves, and there is a tendency for them to become hollow and to form either the first stage in a longitudinal division or, as undoubtedly happens, a new head from which a tail develops. Many specimens of splitting spirochaetes are to be seen, and figures like those shown in Fig. V, *a*, indicate very clearly that the organism splits longitudinally; but this splitting, where it does not occur throughout the whole length of the filament, produces a sphere in the middle or at the end of the spirochaete which itself is the beginning of a new filament (Fig. V, *b*). It would appear

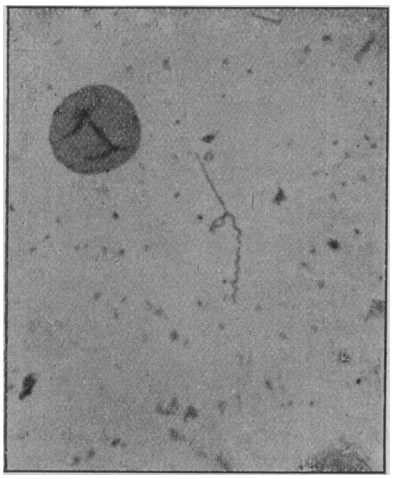

Fig. VI.—Photomicrograph of *Spirochaeta pallida* with head attached, developed (?) from an excrescence. Ringbody at side of one end. (× 1800, taken by Dr. Buchanan from same film as Fig. III, 2.)

as if the formative power were in a greater hurry to produce numbers than to take time to form a complete spirochaete, the reproductive force exhausting itself in quantity rather than quality.

As further evidence in favour of the view that the sphere formation is not always due to splitting, it has been found not infrequently that the sphere is solid, and from this a fine filament develops as in the earlier stage. Fig. VI shows a type of spirochaete whose form can be explained by the development of a hollow sphere from a dot on the top of the curve, but at the same time it might conceivably result from the divergence of the limbs of a partial split, though the inequality of the limbs does not favour this view; without the excrescence the configura-

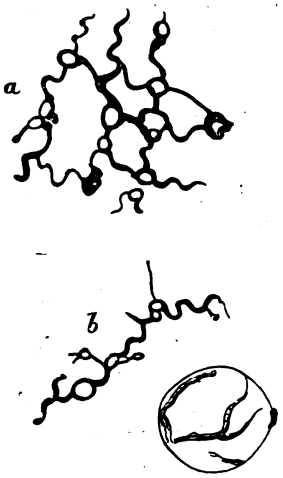

Fig. VII.—Drawing from composite types of spirochaetes seen in smear stained with Giemsa and then with acetone gentian violet. There was a typical primary sore without secondaries. Notwithstanding a full mercurial treatment the secondaries have since developed. *a* Shows three main spirochaetes so attached as to form a colony, and fully establishing the view that the small-tailed bodies and the spirochaetes are the same organism. *b* Is a single spirochaete showing the beginning of the colony formation or breaking up of the spirochaete.

tion is that of a typical *S. pallida*. Certain figures are to be seen which are either due to an almost complete split or to two spirochaetes touching at corresponding points. This no doubt occurs or can occur accidentally, but when other configurations show the split to be less complete and the split parts to be attached by a more or less straight solid rod, then the view that the picture is due to a longitudinal fission is much more probable. I have

searched for a long time to get proof of the other method of division, and have found very distinct evidence of its prevalence. Such configurations as those shown in Fig. VII, most carefully drawn from actual specimens, show clearly that the sphere formation may not be a fission, but the actual development in the spirochaete of material out of which a new part is to be formed. It indicates that the spirochaete may break up into innumerable small bodies. Here are seen three main spirochaetes (*a*) with branches from the spheres or dots

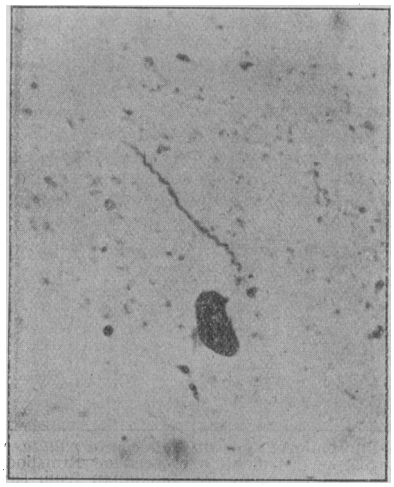

Fig. VIII.—Photomicrograph of typical *Spirochaeta pallida* with straighter part about the middle. Distorted red cell at side, ring and tailed bodies scattered over the field. (× 1800, taken by Dr. Buchanan from same film as Fig. III, 2.)

formed on the surface; the parts taken by themselves show very clearly what is the relationship between the *Spirochaeta pallida* and the small-tailed bodies. It is therefore not necessary for the organism to form a typical *Spirochaeta pallida*, but the multiplication may go on indefinitely without the formation of such forms, and when such are developed they may break up into the small bodies, so completing the cycle. These small bodies may remain attached to each other, and an indefinite mass be formed, or they may separate at once. This explains to me the very common experience of all workers who have been unable to find the spirochaetes invariably. There can be no doubt that the *Spirochaeta pallida* is one phase only in the life-cycle of a protozoon, for the somewhat complicated and long filament cannot spring into mature being suddenly, and when other similar types are to be found side by side with it, a presumption exists that they are related to it.

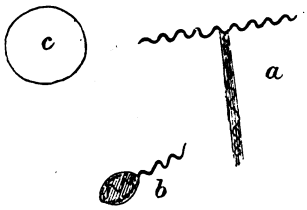

Fig. IX.—Diagram of (*a*) spirochaete with another attached, showing albuminous ribbon: (*b*) spirochaete with albuminous "head" surrounding part, or spirochaete penetrating an albuminous body similar to such as are described by Siegel; (*c*) outline of red cell for comparison.

Figure X, 1, shows what is usually accepted as being a white cell, but I would throw doubt upon this as I have seen the regularity of the form to be more or less constant and have seen it frequently in smears from syphilitic sores and nowhere else. The protoplasm of the nucleus stains much more faintly than that of the white cell. Further, the tail may be noticed to be splitting just as the spirochaete does; there can be no confusion between this and the spirochaete, because the one body is infinitely larger than the other. The latter body can be easily seen with a low power, whereas the spirochaete cannot. Whether this is a necessary part in the life-history of an organism connected or not with syphilis remains to be proved, but its presence with the other protoplasmic organism is to be recorded. In the *Spirochaeta pallida* the head is sometimes so large as to render the resemblance between it and the larger body somewhat striking.

The name *Spirochaeta pallida* only denotes one stage in the history of an organism, while the *Cytorrhyctes luis* probably denotes another. If the contention shortly set forth in the BRITISH MEDICAL JOURNAL in March, and more fully in this paper, is supported by other observations, another name will be required for the protozoon found with, or as the cause of, syphilis. It is also possible—if not, indeed, probable—that there is more than one organism responsible for the series of symptoms included in syphilis. It is a striking fact that the symptoms of syphilis during the roseolar stage are so slight, yet the blood and tissues are more or less contaminated by hordes of micro-organisms. Such symptoms as are present are not likely, therefore, to be due to a toxin elaborated by these germs, but to the germs themselves. Do they fuse with the protoplasm of the cells and thereby cause the chronic deterioration of the whole body, the severity of the disease becoming manifest when the micro-organisms have vanished?

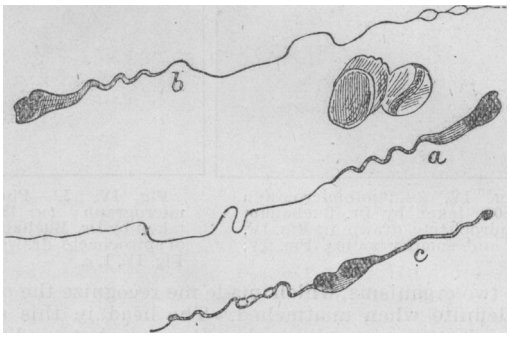

Fig. X, 1.—Diagram of (*a*) long-tailed protoplasmic bodies found frequently in smears from syphilitic discharge. The deeply-stained part of the head may be partite. (*b*) The neck is straight and is continued into a waved (three or four) portion, then into a long fine filament which is quite as delicate as a spirochaete. The filament may show partial longitudinal splitting (*b* and *c*), it may also end in a little mass of protoplasm (*c*). (*c*) Also shows the nucleated part to be central. Three red cells are drawn to scale.

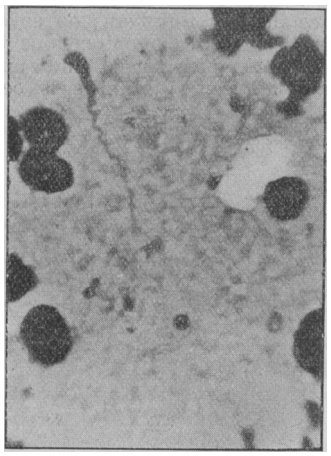

Fig. X, 2.—Photomicrograph of specimen drawn in Fig. X, *a* (× 900). Film stained with Giemsa, then acetone gentian violet.

Regarding the differences between *Spirochaeta pallida* and *refringens* I have failed to find the *Spirochaeta refringens* with heads or with excrescences upon their curves. I have also failed to find the flagella at the ends of either organism. *Spirochaeta refringens* divide longitudinally and transversely. The longitudinal method of division I have only noticed in the short forms (Fig. XI, *a*); I have never seen the formations described in this paper for *Spirochaeta palllida* (as if two filaments had almost, but not quite, separated) imitated by *Spirochaeta refringens*. The method of transverse breaking up occurs in the longer filaments. The appearance seems to be the formation of spores, which result in a chain of dots (Fig. XI, *b*) lying in an almost invisible filament. Occasionally signs of simple transverse division are to be seen—*Spirochaeta refringens* breaking into two or three shorter ones. With practice the

differences between the two may be easily enough recognized, and the intermediate forms distinguished. When the spirochaetes are numerous they are likely to be *Spirochaeta refringens*. The variation in the degree and kind of the curves (slightly waved, straight, or spiral existing on one film) proclaims the *Spirochaeta refringens*. When *Spirochaeta pallida* exists side by side or in the same specimen, the divergence of form removes all doubt as to the organism under observation. The fact that *Spirochaeta refringens* has been found in the lymphatic glands at least once should cause one to take note of the presence of this spirochaete more carefully.

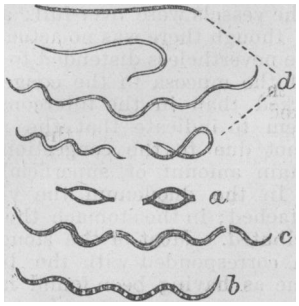

Fig. XI.—Diagram of short *Spirochaeta refringens*, showing: (*a*) longitudinal fission; (*b*) spore formation; (*c*) transverse division by attenuation of part; (*d*) various forms taken by the organism. Drawn from a film stained with acetone gentian violet from a primary commissural chancre. The film also contained the *Spirochaeta pallida* in fewer numbers.

I have to thank Dr. Thomas Kay, the Visiting Surgeon, and the Resident Staff of the Glasgow Female Lock Hospital for their assistance in this investigation; and I am much indebted to Dr. Leslie Buchanan for the vast amount of time and trouble he has taken in photographing the specimens.

Since writing this paper I have read Siegel's third paper,[4] and while I have named the bodies which I think are the progeny or the progenitors of the *Spirochaeta pallida* as *Cytorrhyctes luis*, they bear a resemblance only to some of those figured by Siegel. With the subject in its present stage, it is not advisable to multiply names given to the organisms found, though already this tendency is very apparent. Schutz's paper,[5] published in March, entirely supports the views set forth in my preliminary communication and in this paper.

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A FATAL CASE OF ACUTE CARDIAC BERI-BERI.

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THE case of acute beri-beri here recorded is one of several that I have had the opportunity of studying through the courtesy of the Committee of the London School of Tropical Medicine. It is the only case that proved fatal. The result of the *post-mortem* examination of this single case, however, largely confirms my previous observations on this disease. The bacterial investigation of the case has not been finished, but enough has been done to warrant pushing the investigation to a conclusion. For this purpose I have handed over to Dr. Dudgeon of St. Thomas's the cultures, not only of a suspicious bacillus found in this case, but of a similar bacillus recovered from the stools of other acute beri-berics. Dr. Dudgeon will report in due course. In the meantime it seems wise to publish the case itself and my own findings in it.

A. A., age 37, a seaman, was admitted to the Branch Hospital of the Seaman's Hospital Society (Dr. Duncan's Clinic) on November 23rd, 1905.

History and Condition on Admission.

Dr. Stanton, House Physician, noted as follows: The patient, a native of Calcutta, made his last voyage from Calcutta on the ss. *Sumatra*, and arrived in London about November 2nd, 1905. The ship went to Antwerp and returned to the Royal Albert Docks on November 22nd. His present illness began on his first arrival in London about November 2nd. There was cough, with pain in the deep epigastric region which he attributed to the cough. He had no appetite and had marked constipation. In a few days his legs felt weak and began to swell. Both the weakness and swelling gradually increased. No history of other illnesses can be obtained. He had not had any venereal disease. He said that ten others occupied the same quarters as himself, and that as far as he knew none of them had contracted his disease. The physical examination was made by Dr. Hamilton Wright and Dr. Stanton. The temperature was 97.4° F., the pulse at rest 112. Respirations 32. The patient was much depressed; brandy had been administered for threatened heart failure. The pulse was small, weak but fairly regular. There was marked dyspnoea. The lips were cyanosed. The apex beat was beneath the sixth rib in the left nipple line. The precardiac beat was somewhat diffuse. The first sound heard at the apex was weak and the diastolic pause decidedly shortened. Occasionally a soft systolic murmur was heard at the apex. The pulmonary and aortic second sounds were frequently reduplicated. The right cardiac dullness extended to the left border of the sternum. There was marked pulsation in the cervical veins. The general character of the cardiac rhythm was embryonic. Large and small moist râles were heard in all parts of the lungs, and there were signs of fluid in the posterior pleurae. The abdomen was distended, and appeared to obtain a considerable amount of fluid. There was marked oedema of the legs, thighs, and sacrum. The patient was slightly dulled mentally from the effects of the brandy administered, and no certain facts could be determined in regard to his sensori-motor condition. The knee-jerks were absent; the superficial reflexes normal. The myotatic irritability of the muscles of the legs and thighs was excessive to direct mechanical stimulation.

The urine for the first twenty-four hours measured 10 oz., specific gravity, 1024; acid, no traces of albumen. The faeces contained some eggs of *A. lumbricoides*, also eggs of *T. dispar*. These disappeared on the exhibition of drugs.

November 24th. A pin can be driven through the skin of the patient's legs without his noticing it if his attention is engaged by conversation. When distraction ceases he correctly locates the pin, and complains of pain. It would seem that dolorific pain is at least delayed. Flexion of the ankles is slow; also extension of the toes. It is difficult to decide whether or not this is due to the massive oedema. The cardiac condition is as first noted. The patient had been given a mixture containing tr. digitalis, spt. ether. nit., and aq. chlorof. every four hours.

On November 27th the patient was as when last noted; 5 gr. of santonin was given.

On November 29th he was still in the same condition as when admitted; sodium sulphate was given.

On December 5th it was noted that many remedies had been exhibited for the dyspnoea and cardiac distress without avail. The oedema had increased, and extended to the trunk. The abdominal wall was markedly oedematous as high as the umbilicus. The scrotum was massive with oedema. The râles in the lungs had cleared up. The sensori-motor condition was not clear; there was certainly no disturbance of either function in the trunk or upper limbs. The legs, however, were apparently dulled to painful and tactile sensations. This might, however, have been due to the oedema. The knee-jerks had been tested nearly every day, and had not been elicited. All other reflexes were normal. Mentally he was clear, but talkative and difficult to keep to the point.

On December 11th, though the lungs were practically clear of all râles, he expectorated a small quantity of blood-stained mucus. The oedema had not subsided. The cardiac condition was as on admission, except that the embryonic character of the rhythm was more pronounced. There was no certain sensori-motor disturbance, except that painful stimulation appeared to be delayed as high as the knees. The reflexes were as on admission. Flexion of the ankles and extension of the legs was certainly slower than the opposite movements, but certain weakness was somewhat doubtful.

On December 18th it was possible to get a certain response to sensory stimulation. Tactile sensation was diminished as high as the knees. There was a slight weakness of the extensors of the legs and of the flexors of the ankles. The cardiac condition was as on admission, except that the irregularity was greater.

On December 24th the condition was unchanged, except that the urine was diminishing in quantity. The patient gradually failed. The oedema did not clear up, and he grew weaker in the legs. It was not possible to determine if the sensory disturbance had extended, as the patient showed considerable irritation and uncertainty on examination. The cardiac sounds and rhythm became more irregular. At 9.30 a.m. on January 1st, 1906, he raised himself in bed, stared round the ward, gasped a few times, and fell back dead.

Dr. Wise made a careful attempt to cultivate organisms from the blood of this case, but failed to do so.