gaged in the internal abdominal ring, and actually be the cause of the patient's death. This happened in one of the cases of congenital hernia which will be described in the next lecture, and in which the herniated intestine could just be drawn as far as the pubic spine. The history of the case states that the hernia was a small bubonocoele. Indeed, so far as the observations have gone, they lead to the conclusion that, as concerns the excursion of the intestines, no one is exempt from the possibility of hernia.

If now we proceed to analyse the cases, we shall find, as might be expected from what has gone before, that the long mesentery of infancy and childhood is associated with a considerable downward excursion of the small intestines. Before the age of 14 the ileum reaches from one to two inches beyond the right crural arch, a rather shorter distance beyond the spine of the pubes, and a yet shorter distance beyond the left crural arch. When the stature of the subjects at the various ages is taken into consideration, it is clear that the excessive excursion of infancy and childhood tends to diminish with adolescence. In seventy-two individuals whose ages ranged from 16 to 89 years, the excursion of the intestine over the centre of the right crural arch, where it is almost always the greatest, varied between three inches and nothing, the large excursion being noted in eleven instances, and the small in twelve. In one other case the excursion was four inches, but this was associated with a low attachment of the mesentery, namely, two inches above the base line; and in yet another case the excursion was three and a half inches, the flexura duodeno-jejunalis being three and a half inches above the base line, with a mesentery nine and a half inches long. Of course, the above only gives the greatest excursion of the intestines over the centre of the right crural arch, but with hardly any exceptions the excursion is less over the spines of the pubes and over the left crural arch. It is quite usual to find in adults that the small intestine will pass an inch and a half beyond the right crural arch, an inch beyond the spine of the pubes, and that it will touch the left crural arch. It is an easy way of representing the downward excursion of the intestines in the adult by fixing a piece of tape or string, seven and a half inches long, to the abdominal wall at the same level as, but an inch to the right of, the umbilicus. The free end of this string passes about the same distance beyond the crural arch and pubic spines as the intestines ordinarily do.

THE MORPHOLOGY OF THE ACTINOMYCES.

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It is obviously a matter of considerable importance to know whether the diseases that are now designated actinomycosis in man and in cattle are identical morbid processes in the sense of being caused by the same micro-organism. It is equally evident that no conclusion, whether affirmative or negative, can be well founded if it does not repose upon an accurate knowledge of all the varieties of form exhibited by the parasite in the two species. In many districts both in England and in Scotland actinomycosis is a very common disease in cattle, and it has within recent years received a large share of attention from the veterinary profession; but this attention has been almost entirely of a clinical nature, the botanical and morphological characters of the actinomycosis itself having received little investigation.

The main object of the present paper is to compensate to some extent for that deficiency by describing in detail the morphological characters of the actinomycoses as it occurs in cattle.

In the great majority of cases of actinomycosis occurring in cattle, the parasite presents itself under the form of minute granular masses, the larger of which are distinctly visible to the naked eye. It is the presence of these granules that gives to the purulent matter occasionally formed at the seat of disease its peculiar characters; and even with the unaided eye, but still better with a lens, the larger granules can be seen as opaque specks in the gelatinous and translucent nodules formed in the tongue and other situations. When a droplet of pus or a scraping from the cut surface of the affected part or organ is spread on a cover-glass and examined unstained under a low power of the microscope ($\times 60$), the colonies are seen as rather opaque granular bodies, varying greatly in size and outline, but all agreeing in having a finely granular surface. The unstained colonies are sometimes colourless, but frequently they exhibit a faint greenish-

yellow tinge. Many of the colonies, particularly those of medium size, show, even with slight magnification, an irregularly radiate pattern, the striae extending from the centre towards the circumference, to which they give a notched or serrated character. Many of the smaller colonies look like sectors of these radiate heaps, and the larger masses, on the other hand, have a coarsely and irregularly sinuous edge, as if resulting from the fusion of a number of radiate colonies. When thin sections are cut in the fresh state with a freezing microtome, and floated in water, the larger colonies in nearly every instance drop out of place, and the section when mounted then presents, if the colonies have been numerous present, a reticulate or spongy character.

Fig. 1 (Reichert's $\frac{1}{2}$ oil-imm., oc. 3).—An ordinary mulberry colony. At the margin are seen horizontally disposed clubs, in the centre optical sections of vertical and oblique clubs.

When the finer structure of these colonies is investigated with a higher magnifying power, and after appropriate staining, the medium-sized more symmetrical colonies show an appearance which has been frequently compared to the flower of one of the Compositae. The rim of the colony shows radiately-disposed, ovoid or club-shaped bodies, while the centre when brought into exact focus appears granular, like the heart of a daisy. It would be equally correct to say that this central part exhibits a fine but slightly irregular mosaic, for careful focussing shows clearly that, while the extreme ends of the separate elements of this granular centre are rounded in form, their deeper parts are polygonal from mutual pressure. Further, it is easy to convince oneself that the elements of the central part of the colony are simply the marginal clubs seen with their long axis in the line of vision.

The separate elements of the same colony are by no means uniform as regards shape and size. Thus some of the clubs are three or four times larger than others, and they show considerable diversity in their outline, and in the proportion of length to breadth.

The characters of the colonies, again, vary a good deal in different cases, the granularity of the centre and the clubbing of the margin being sometimes very pronounced, while in other instances each colony shows only a faintly granular centre and a correspondingly almost plain edge.

What has just been said applies, of course, merely to the surface structure of the colonies. When an attempt is made to ascertain the structure of the core of each mass, either by crushing it in the fresh state between the slide and cover-glass, or by examining sections which pass through the larger heaps, one fails in the great majority of cases of the bovine disease to find any distinct formed elements except the clubs. In many of the smaller colonies there appears, in fact, to be no actual core, the entire mass being composed of the already-described club-shaped elements, and the central part being occupied by the closely appressed tapering ends of these same bodies. In other instances there is a diffusely staining and obscurely granular nucleus, but in the ordinary mulberry clubbed colonies no mycelial structure is discoverable.

It thus appears that in actinomycosis of cattle the most constant, and in many cases the only, distinct elements of the fungus colonies are the so-called clubs. Naturally, therefore, in discussing the actual nature of the organism, and in attempting to settle its proper botanical position, attention has been turned chiefly to these bodies. Nevertheless, they are of far less importance from that point of view than the less frequently encountered structural elements that without doubt in the growth of every colony precede them.

The mulberry masses of clubs which are found in every actinomycoma of cattle represent only a single phase of the growth and development of the actinomycoses. This type of structure is, in fact, the last stage in the progress of the parasite within the tissues, and there is some reason to believe that in the great majority of such colonies not a single element has retained the power of vegetation. But when an attempt is made to trace back the history of development of these collections of club-like bodies, much difficulty is usually encountered, for in almost every tumour

which has been in existence for any considerable period of time, the colonies, however numerous they may be, show little variety, except in size and in the mode of grouping of the clubs. Occasionally, however, a tumour may be encountered which shows the earlier stages of development of the actinomyces, and during the past year I was fortunate enough to obtain an actinomycoma in which the life history of the organism may be clearly traced.

This tumour was taken from a cross-bred three-year-old ox, which was exposed for sale in one of the Edinburgh cattle marts. In passing through the mart I observed that the animal had a peculiar tumour projecting from the left inguinal region, and on closer inspection the growth appeared to be connected with the stump of the spermatic cord. Suspecting that the tumour was an actinomycoma, I made arrangements for its coming into my possession, and on the following day I visited the abattoir, and had the growth excised while the carcase was being dressed. An incision having been made into the tumour, and a small piece having been cut out for immediate examination, the remainder was forthwith put into strong spirit. The tumour was rounded in form, and about twice the size of the fist. It projected freely from the surface of the body, and might, on a casual inspection, have been mistaken for the scrotum and testicles. Superiorly it was connected with the stump of the spermatic cord, and towards the centre of its free or inferior surface it was denuded of skin over a considerable area. The surface of the tumour was here partially covered with thin brown crusts formed from coagulated blood, and it exuded in drops an amber-coloured, almost clear fluid. Its consistency might be described as sarcomatous or fleshy, and on section it showed a faint pink, firmer ground substance, with scattered softer points, the largest of which were about the size of a grain of barley. These points were not exactly miliary abscesses, to which, however, they bore some resemblance. They had soft solid rather than liquid contents. The contiguous lymphatic glands were slightly enlarged, but not visibly altered in structure, and a subsequent microscopic examination did not reveal in them any actinomyces or other organisms. There were no other tumours present in the body, and all the organs appeared to be healthy. Examination of sections made in the fresh condition, and of the material from some of the softer foci, showed, on staining with picro-carmin, that the tumour was of the nature surmised. Each softened centre appeared to contain an actinomyces colony, which, however, differed notably from the common form in that only a few clubs could in most cases be discovered at the margin. Moreover, the colonies were easily disintegrated by pressure, and they then showed an abundant finely granular centre.

In this, as in most other tumours of the kind, the examination of the actinomyces colonies cannot be accurately carried out except in thin sections cut from pieces imbedded in paraffin or celloidin. The majority of the sections here figured were imbedded in the former of these media, and cut with a Cambridge rocking microtome. They were subsequently fixed on the slide with albumen and glycerine, or clove oil and collodion, and stained by Gram's method. This procedure is incomparably superior to that of staining the crushed or otherwise disintegrated colonies, for with a section sufficiently thin the individual elements can be seen plainly, and with their normal connections undisturbed. In thin sections treated in this manner the larger colonies, each of which corresponds in position to one of the soft foci previously referred to, are plainly visible to the naked eye as deeply-stained violet specks (stained with gentian violet). The appearance of one of these when magnified about forty times, is depicted in Fig. 2. The outline of the groups is irregular, being

Fig. 2 ($\times$ about 40).—A large actinomyces colony. The radiate character of the margin of the colony is caused by dense columns or packets of cocci, with occasional thread-forms in between.

sometimes approximately circular, in other cases oval, and occasionally elongated or elliptical. In most of these larger colonies the densest part lies a little within the outer edge, which some-

times has the appearance of a delicate fringe, due to a radial striation. In every case the soft spots of the tumour contain one such large colony, and sometimes two or three.

When a colony such as that shown in Fig. 2 is examined under

Fig. 3 (Reichert's $\frac{1}{4}$ oil-imm., oc. 3).—Part of the margin of a large colony, similar to that depicted in Fig. 2. At the margin are seen masses of cocci, irregularly grouped and in chains. Within this (to the right) are commingled cocci and filaments. A long filament, segmented at its inner end, is seen shooting out between the marginal cocci.

a high power ($\frac{1}{4}$ oil immersion), it is seen to contain elements of three different forms, namely (1) minute cocci, (2) thread-like forms, and (3) clubs. The first and second of these varieties are invariably present in the large colonies, but in many instances the club-like bodies are absent.

1. *Cocci*.—These are by far the most numerous elements in the larger colonies, throughout the whole of which they are frequently found. In the centre, however, they are less abundantly present than elsewhere. In the densest part of the colony, in what may be called its intermediate zone, they occur in close heaps, intermingled with filamentous forms. The fringe-like marginal part of the colony is mainly made up of cocci disposed for the most part in dense packets, the long axis of each packet having a radial direction. The fringe-like appearance of the margin is due to these packets, separated by slight intervals through which leptothrix forms frequently shoot out. The size of the cocci is slightly variable, though as a rule tolerably uniform in the same group. Their diameter measures about 0.5μ . The elements are for the most part quite circular in outline.

A notable feature of these cocci is their tendency in many instances to form chains. In the denser heaps no such tendency can be made out, but in the thinner marginal packets there are many beautiful chains, comprising sometime ten to fifteen elements, and frequently slightly curved or wavy. At the same time, in many of the smaller masses in which each element is clearly visible, the cocci are irregularly heaped together. In other words, these elements sometimes exhibit a streptococcus, and at others a staphylococcus, arrangement.

Finally, it is to be observed regarding these cocci, that in the less dense parts of a colony there are discernible occasional distinct diplococcus forms, and elements that appear to be in the act of dividing.

Some doubt may be entertained regarding the propriety of calling these elements cocci. But it appears to me that no good purpose would be served by terming them coccus-like, and certainly no one seeing them, and being unaware of their situation and of their relationship to the elements yet to be described, would hesitate to call them cocci.

Thread-like Forms.—These are constantly present along with the elements just described in all the larger colonies. Towards the centre of the colony they are irregularly disposed; but in the intermediate dense zone they assume for the most part a radiate direction, and in the marginal part that is pre-eminently their arrangement. In the latter situation they frequently shoot out in a tendril-like manner beyond the coccus heaps already described. The length of the threads is extremely variable, from short bacillary segments up to filaments that extend through one quarter of the field of the microscope. Their breadth is also somewhat irregular in different threads, and even at different parts of the same filament. I estimate that on an average their breadth is about 0.6μ . Some are nearly straight, others gently curved, and occasionally they show short undulations almost like a spirillum. This last form, however, is very rare. In the denser parts of a colony, where the threads are felt together, it is often

difficult to discover whether they are branched or not; but at the margin there is no difficulty in finding distinctly-forked filaments, though such forms are always far less numerous than the simple unbranched threads.

Fig. 4. (Reichert's $\frac{1}{2}$ oil-imm., oc. 3).—From the opener part of a large colony. Shows irregular groups of cocci and variously segmented filaments.

As already said, the threads frequently vary in breadth from point to point, and sometimes they might be described as varicose. Many of the shorter threads, however, appear uniform in breadth.

In most cases the threads appear undivided, but others are distinctly segmented. This segmentation takes two forms. (1) In some threads it is very irregular, and it is possibly sometimes evidence of degeneration or incipient death of the filament. (2) Some of the filaments exhibit a segmentation which, from its regularity, and from the depth of staining of the segments, must be interpreted as evidence of active growth. Finally, with regard to these filaments, it is of the greatest importance to note that careful search discovers transition forms between the unsegmented and segmented threads, and between the latter and the chains of cocci. That is to say, it is possible to find filaments which in one part of their course are undivided and at another part regularly segmented, and segmented or unsegmented rods continuous at one end with a short chain of cocci. In such articulated filaments it is sometimes possible to discern between adjacent segments an unstained connecting material.

Fig. 5. (Reichert's $\frac{1}{2}$ oil-imm., oc. 4).—Group of irregular (degenerating?) elements from a large colony.

Club-like Forms.—From the constancy of these elements in the ordinary actinomycetes clumps of the bovine disease, and from the importance that appears to be attached to their presence or absence in human actinomycosis, it was evidently of great interest to discover whether they were present in this case, and further, if possible, to elucidate their relationship to the elements already described.

As already stated, the fact that they were present had been observed in the examination of sections made in the fresh state, and a study of them in stained sections from the preserved tumour enables me to describe and to figure them in a more detailed manner than has yet been done, at least in the case of the bovine parasite.

In the first place, with reference to their occurrence here, in many of the larger and more luxuriantly-growing colonies they are entirely absent. Fortunately, however, in a considerable number they are numerous present, though never in such numbers as to conceal the other elements of the colony. I say fortunately, for had they been entirely absent the form exhibited by the parasite would have lost its value as a connecting link between some of the cases encountered in the human subject and those commonly met with in cattle.

In all the large colonies the clubs when present are confined to the margin, that is, to the surface of the mass. Here, as in the common form of the parasite, they are radiately disposed, with their broad end outwards. The size and exact form of the clubs

Fig. 6. (Reichert's $\frac{1}{2}$ oil-imm., oc. 4).—This figure represents special elements selected for illustration from various colonies. 1. Short chains of cocci; 2. Irregular group of cocci, from which proceeds a filament ending in—3. a club, showing an axial deeply-stained thread in direct continuity with a filament, and surrounding that a faintly-stained cortical substance; 4. A club with deeply-stained axial particles (cocci?); 5. A club in direct continuity with a segmented filament; 6. Two spherical elements staining like clubs; 7. Cocci developed by close segmentation of a filament; 8. Formation of cocci within unstained continuation of a filament.

vary very greatly. As a rule their dimensions are somewhat less than in the common mulberry heaps met with in cattle, but I have discovered a few of very large size. Some are very much drawn out in the direction of their length, and others are ovoid or nearly circular. The majority, again, are quite simple; but some carry lateral buds, and occasionally two appear to be carried by a common stalk.

Fig. 7 (Reichert's $\frac{1}{2}$ oil-imm., oc. 4).—Part of a medium-sized colony. Shows central cocci and marginal clubs of various sizes and shapes.

In some of the colonies treated by Gram's method with gentian-violet, the majority of the clubs are very faintly stained, some being scarcely visible. In others, again, they stain intensely by this same method. Carbol-fuchsin stains them brilliantly. Many of the clubs appear unconnected with the other elements of the colony, but in many others (presumably younger forms) the direct connection between the club and one of the leptothrix or cladothrix filaments is quite obvious. In the more deeply-stained clubs it is impossible to observe any details of structure, but in some of those only faintly tinged two distinct parts are discernible, namely (1) an axial, more deeply-stained thread, in direct continuity with a filament emerging from the colony, and (2) a faintly-stained material surrounding this thread, and forming the main part of the club. It is of further interest to observe that sometimes the axial thread is segmented just like the filament of which it is a prolongation, and in a few instances it has appeared to me as if the axial thread were represented by a short chain of cocci. This, however, might be due to degeneration of the thread, and in the case of every large club signs of arrested growth or incipient decay are observable in the filament with which it stands in connection, the filament being finer than usual and staining faintly. Moreover, by a very careful focussing and adjustment of the light, it is sometimes possible to follow the central narrow end of a club that at first sight appears detached into a filament that has ceased to stain. Some of the clubs stain in a patchy manner, as if in a state of degeneration.

The irregularity of size and shape of the clubs has already been mentioned, but it remains to be said that there are occasionally found around the margin of a colony, and less frequently within it, elements that have no title to be called clubs, or to be included under that head when regard is paid solely to their shape. Many of these, which are upon the whole smaller than the clubs proper, but much larger than the cocci, are quite circular in outline. But the behaviour of these bodies towards staining reagents and their refractile appearance clearly mark them out as being identical in nature with the clubs, and indeed there are numerous

transition forms between these and the regularly club-shaped elements.

Fig. 8.—(Reichert's $\frac{1}{2}$ oil-imm., oc. 4.) A small colony showing cocci, short irregular filaments, and clubs.

Hitherto attention has been confined to the larger colonies, but there remain to be described some important points in connection with the smaller groups of elements.

In passing out from the margin of a large colony into the mass of round cells (leucocytes) in which it is imbedded, one meets here and there with cocci, singly, in short chains, or small groups. These appear to me to have been transported from the margin of the large colony by the agency of the leucocytes, and to furnish the seed for new centres of growth. The majority of these scattered cocci are contained within the cells, and some lie within the nuclei. Occasional short single threads are also met quite near the margin of the large colonies.

Fig. 9.—(Reichert's $\frac{1}{2}$ oil-imm., oc. 4.) A commencing colony. 1. Group of cocci. 2. Diplococci. 3. Cocci within nuclei. 4. Very short rod-forms, probably developed from cocci.

The preceding small groups of cocci are, of course, distinctly visible only with the higher magnification ($\frac{1}{2}$ oil immersion); but when a section is scanned with a low power, one observes usually a number of colonies of very various sizes, from those measuring 0.75 millimètre in diameter, down to such as are just visible as a stained speck. The medium-sized colonies do not differ in any important respect from the larger already described, but the smaller of the groups exhibit great variety as regards the grouping of their elements. All except the very smallest contain both cocci and thread forms, but some of the more minute colonies are entirely composed of cocci. The arrangement of the threads and cocci is sometimes irregular in these small groups, the thread forms being interwoven, and the feltwork thus formed containing groups of cocci. Very frequently, however, threads shoot out in a radial direction from the centre of the group, to which they give a spider-like appearance under a low power. Many very small groups show clubs, and sometimes in relatively large numbers. Sometimes the narrow or central end of the club is lost in a group of cocci.

Fig. 10.—A small colony, showing central core of cocci (partly out of focus), and radiating filaments, some of the latter being branched.

In the discussion which followed the reading of the paper on a Case of Actinomycosis Hominis, before the Royal Medical and Chirurgical Society on February 12th last, great stress appears to have been laid on the presence or absence of clubs, and even on the staining reactions of these bodies as indicating the identity or non-identity of the actinomycetes found in man and in cattle. The case that I have just described proves beyond any doubt that these points ought to have little or no weight; for here, in the same tumour, many colonies show not a single club, while in others they

are numerous. Moreover, in some of the colonies the clubs stain so faintly as to be just visible, while in others similarly treated they stain brilliantly.

In order to show the close correspondence of the elements present in this bovine actinomycoma, I may here refer shortly to Israël's description of the parasite as found in man.¹ Israël enumerates three morphological elements in the granules or colonies:—

1. Long undivided mycelial threads, almost always wavy, curved, or corkscrew-like. These threads may be at one part straight, then wavy, next spiral, and again straight. The threads frequently branch dichotomously, are mostly rounded, but sometimes flat or band-like, and of very variable length. They are sometimes closely felted together like entangled masses of hair, sometimes they have a sheaf-like arrangement, running more or less parallel to one another.

2. Israël describes as the second morphological elements of the colonies minute granules (*Körnchen*) of various sizes, which, he says, one would certainly identify with the ordinary coccus if encountered without the other constituents of the colony. Of these, again, he recognises two varieties, namely, a small, pale, slightly refractile variety, these being the most numerous, and a larger, very refractile form, frequently not quite round, but more oval, and even angular. These cocci are infiltrated in the meshes of the interwoven threads, but places occur where they are found alone.

3. The third constituents mentioned by Israël are the pear- or club-formed bodies, which exhibit great variety as regards size and proportion of length to breadth.

Israël characterises the third of these forms as the most remarkable, and he describes them at greatest length, and figures them in most detail. The above description refers to Israël's earlier cases, but it is worthy of notice that in a later case² in some of the colonies the only elements present were the threads, although in most heaps coccus-like forms were also present. Still more important is it to observe that in this same case the clubbed elements were absent in most of the colonies.

Ponfick,³ as the result of his examination of the parasite from cattle, declares that in all essential particulars it agrees with the organism found in man. But in his enumeration of the constituent elements of a colony he entirely ignores the coccus forms. He describes each colony as being composed of three elements: (1) an intricately interwoven arrangement of fibres forming the nucleus or centre of the colony, (2) an intermediate zone of radially disposed threads, and (3) an outer zone of club-like terminal segments.

Ponfick's figures are entirely devoted to showing the varieties of the club forms and their mode of connection with the so-called hyphæ. An examination of these figures gives me the impression either that he selected for illustration exceptional forms, or that the club-bearing filaments in man are much more frequently branched than in cattle; but as Ponfick had attentively examined the bovine as well as the human parasite, his opinion that they are identical must be accorded great weight.

It thus appears that in the actinomycetes colonies, whether occurring in the tissues of man or of cattle, three morphological elements may be found, and it remains to inquire what are the inter-relationships of these three forms.

Harz, who examined the organism in specimens submitted to him by Bollinger, named it the actinomycetes, and assigned it a place among the mould fungi.⁴ Harz described each actinomycetes heap or colony as being composed of a number of unequal (in size), mostly wedge-shaped, segments, each of which represents a complete individual. The latter, he says, begins at the pointed end of the wedge, with a somewhat conical basal cell, which, in the absence of a mycelium, possibly represents the same, and which carries a great number of short-segmented hyphæ. The hyphæ divide themselves in an irregularly dichotomous manner, and terminate ultimately in a great number of end-arms. On the branches of the homogeneous or finely granular hyphæ sit the short-stalked gonidia, which are, like the hyphæ, polymorphous, showing oval, round, or longish club-shaped forms. From the broad end of the gonidia buds grow out, and develop into long cylindrical tubes. At the anterior end of each of these tubes the same process is repeated, until the fungus has reached its normal size. Finally, out of the terminal branches grow the gonidia;

¹ Virchow's Archiv, Band lxxiv, p. 18, et seq.

² Virchow's Archiv, Band lxxviii, p. 429.

³ Die Actinomycose des Menschen, Berlin, 1882.

⁴ Centralblatt f. die med. Wissenschaften, 1887, p. 481.

out of each of the gonidia an individual develops itself in the manner described, and out of the numerous gonidia of the latter a mulberry-like colony.

It is evident that this account of the life-history of the organism is incomplete, inasmuch as it altogether fails to take into consideration one of the constituents of many, if not all, actinomycetes colonies—namely, the coccus forms. In the second place, no subsequent observer has been able to identify Harz's basal cells, and his attempt to represent each filament of a colony as being a part of a *Pilz-individuum*, and each colony as being an aggregate of such definitely-formed individuals, appears to me to be entirely fanciful.

J. Israël considered that the parasite, so far as the coccus forms and filaments are concerned, corresponded with the streptothrix *Forsteri*, and Cohn, who had inspected his preparations, confirmed this opinion. Israël⁵ thus summed up his views of the relation-

Fig. 11.—Upper jaw of an ox, showing the bone lesion produced by actinomycosis.

ship of the various elements found in the actinomycetes colonies:

1. The slightly refractile micrococcus-like granules grow out to undivided wavy threads, which are at some places corkscrew-like, and not seldom dichotomously divided.

2. The threads throw off lateral and terminal shining spores.

3. The heaps of very fine pale granules are to be regarded as the offspring of these spores.

4. In special conditions (in Pasteur's fluid) these fine pale cocci may be thrown off from broad faint protoplasmic bands.

5. Some of the threads become strongly refractile at their free ends, and swell out to the form of a pear.

6. The pear-shaped ends (gonidia) can break up through transverse division into a series of segments.⁶

7. The pear-shaped bodies become free, and by budding (apparent longitudinal division), constriction and segmentation accomplish a series of metamorphoses whose ultimate result is the formation of shining irregular-shaped fragments and granules.

8. Out of the latter develop probably the smallest pale micrococcus-like granules which can further grow out to threads. The minute cocci (*Körnchen*) can thus arise in two ways—namely, from the pear-formed gonidia, and from spores thrown off laterally or terminally from the threads.

Johne's⁷ view of the mode of development of an actinomycetes colony is as follows: To begin with, it is composed of a fine non-septate mycelium beset with numerous micrococci, possibly the point of origin for the former. The threads, which grow out in all directions, swell out at their ends into pear-shaped or club-shaped gonidia. Through one or more superficial buds and outgrowths, which, as a rule, proceed only from the base of the gonidia, but sometimes also from the subjacent part of the hyphæ, there are produced cylindrical or club-shaped structures, which grow out to shorter or longer hyphæ. The ends of these hyphæ again broaden out to club-like gonidia. A transverse splitting-up of the latter, a throwing-off by constriction of spore-like segments from the blunt end of the terminal or primary gonidia, and of bud-like elements from the base of the same, appear also to occur. In this way the colony steadily grows at the periphery, while a finely granular disintegration takes place in the centre.

Ponfick refrains from formulating any scheme of development of the actinomycetes clumps, but he expresses doubt regarding the claims of the club-like structures to be regarded as gonidia.⁸ Boström⁹ was led, first from his microscopic examination of the actinomycetes as found in men and animals, and, secondly, from his culture experiments, to regard the clubs as the result of pathological or degenerative changes in the threads, comparable to the so-called "involution forms" of several well-known organisms. By appropriate staining he could in many cases recognise in the centre of the club a coloured thread, which, when the club was divided, could be followed into several or all of the processes. It appeared to him as if a semi-translucent refractile material had been deposited around the thread, the material being in greatest amount at the end of the club, and gradually tapering below until it was lost on the membrane of the thread. In Boström's cultures the clubs never vegetated, and soon perished if not already calcified; but the central filamentous part, even when the peripheral part was calcified, grew quickly and abundantly. His cultures were made from animals in five cases, and from the human subject in one instance, the result in all cases being the same. The cultures for the first two days were found to consist of threads, but later short rods and coccus forms were found lying free and in the threads. Frequently, but especially in the deeper layers of the cultures, and where the nutritive material was exhausted, long club forms were found. Boström therefore concluded that the actinomycetes belongs to the cladothrix group of the schizomycetes, and that it is possibly identical with the streptothrix *Forsteri* of Cohn.

My own observations agree in the main with Boström's views above quoted. I have not been able to find in the colonies of any age evidence that the so-called clubs are at all concerned in the reproduction of the organism. They appear to me to result from a local development of a hyaline envelope of the filament with which they stand in connection. The filament itself, frequently even before the club is fully formed, degenerates and disappears, and the club subsequently never gives evidence of spore formation, or of being a centre for new growth. Moreover, it is, I think, possible that bodies differing from the common clubs in shape, being almost or entirely spherical, but agreeing with them

⁶ Transverse fragmentation of the clubs may frequently be seen in colonies that have been teased or crushed, but I have never observed anything like segmentation of these elements in imbedded sections.

⁷ Bericht über das Veterinär-Wesen im König. Sachsen., 1879, p. 155. Quoted by Ponfick, loc. cit., p. 67.

⁸ Loc. cit., p. 71.

⁹ Verhandlungen des Congresses für innere Medicin, Wiesbaden, 1885, p. 94.

in their staining reactions, may result from the development of a thick hyaline envelope around one of the coccus elements.

The coccus and filamentous forms are the active vegetative elements of the parasite; and as regards the part played by each in the growth of a colony, they appear to be of nearly equal value. On the other hand, I believe it probable that the cocci are the more important as regards the formation of metastatic new centres. I have already stated that around the actively growing colonies single and small groups of cocci are frequently to be found within the leucocytes. Doubtless some of these perish through the agency of the cells, but not rarely a small group of cocci may be seen within the cell body or even inside the nucleus, affording evidence that the cell has not been able to restrain the growth and multiplication of the coccus which it has ingested.

It may, of course, be surmised that precisely the same thing may occur in the case of short segments of the thread forms, but the larger size of these would be less favourable for their transportation. Moreover, certain points in connection with the structure of the colonies may be interpreted as evidence that the filaments offer a slighter resistance to the attacks of the animal cells than the cocci do. Thus, in all the larger colonies of the tumour previously described, the central and intermediate zones contain both filaments and cocci; but at the periphery of the colony, where the struggle between the parasite and the cells is chiefly carried on, it generally happens that only an occasional thread succeeds in shooting out between the dense masses of apparently actively multiplying cocci.

Another point of very considerable interest and importance in this connection is that I could never discover even a small clump composed entirely of filamentous forms; while, on the other hand, there are to be found commencing colonies without any other elements than cocci, and many others showing a great preponderance of these.

It has been suggested that the coccus elements originally described by Israël were probably accidental pyogenic organisms; but I have shown that they may be found abundantly where there is absolutely no suppuration. Moreover, that they are in any sense accidental organisms growing side by side with the actinomyces is negated by their almost constant relationship to the filamentous forms, and by the fact that the latter can be seen in the act of resolving themselves by segmentation into cocci. Nor can they be regarded as spores. The extremely dense heaps in which they are frequently found are not explainable on any other supposition than that they actively multiply after the manner of ordinary cocci. I am inclined to think that these cocci are present in the earliest stage of every colony, but it may well happen that in some cases they soon become overshadowed by a rapid development of filamentous forms. Cultivation experiments may be expected to throw light on the at present obscure point as to what special circumstances determine the parasite to assume at one time coccus forms, and at another to grow mainly in the form of leptothrix or cladotrix filaments.

I purposely refrain from expressing any opinion as to the precise position of the actinomyces among the schizomycetes, as that is a matter which may be fittingly left to botanists to decide, but the history of an actinomyces colony I would venture to summarise somewhat as follows:

1. It has its starting-point in one or more cocci transported by the plasma currents or by the agency of a carrier cell (leucocyte).
2. The cocci multiply by elongation and subsequent fission. When undisturbed by the surrounding leucocytes, their growth and multiplication are after the manner of a streptococcus, but frequently they become irregularly grouped together (staphylococcus heaps).
3. By elongation some of the cocci give rise directly to short bacillary forms, and through these to long filaments.
4. The further extension of the colony is effected by the growth and multiplication of both threads and cocci. The former multiply by segmentation into bacillary elements, which may again elongate to leptothrix forms.
5. The leptothrix filaments may give rise by close segmentation to coccus forms.
6. The formation of clubs and such forms is evidence of diminished vegetative power of the filaments (possibly also cocci) in connection with which they originate.
7. The growth of a colony may be arrested at any stage by the agency of the animal cells (leucocytes), or by failure in the supply of the necessary pabulum. In that event the majority of the

threads tend to develop clubs at their outer ends (involution forms). The central cocci and the remainder of the filaments then disintegrate; but the clubs, which offer a greater (passive) resistance to the surrounding cells, may persist for an indefinite period.

ON THE ADULT MALE FILARIA SANGUINIS HOMINIS.¹

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THE life-history of this form of filaria is of great interest, especially to medical men in Africa, India, Ceylon, the Straits Settlements, China, Australasia, the Pacific, and South America, as certain forms of hæmaturia, chyluria, elephantiasis, lymph scrotum, with other forms of lymph obstructions and the disease known in Africa as "craw craw," appear to be connected with its presence and development in the human body.

These drawings of portions of the male and female filaria were

Fig. 1.—Anterior portion of female: *m*. mouth; *ph*. pharynx; *g. p.* genital aperture; *z*. enigmatic body; *a*. broken extremity.

Fig. 2.—Posterior portion of male: *a*. broken extremity; *f*. testicular products showing through the cuticle; *b*. caudal extremity (? anus); *s*. spicula.

Fig. 3.—Caudal region of same specimen; one of the spicula is drawn *in situ*; *a*. the free extremity.

Fig. 4.—The other spiculum from the same specimen which became dislodged during manipulation; *a*. the portion which becomes the free extremity when the spicule is *in situ*.

exhibited at the Pathological Section of the annual meeting in August last. They were very kindly made for me by my friend, Professor A. G. Bourne, of the Presidency College, Madras, and a

¹ Read before the South-Eastern Branch.