THE PATHOLOGY OF LEPROSY;
WITH A NOTE ON
THE SEGREGATION OF LEPERS IN INDIA.

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THE following remarks are the result of observations made in Western India, 1860-71.

I. *The pathology of leprosy.*

1. *Summary of diagnostic and anatomical characters:—*
1. Alterations in the *skin*.—These are either (*a*) produced by the so-called “tubercles,” whose appearance is well known in Europe; or (*b*) such as are now frequent in the East, and characterised by atrophy rather than by swelling; these latter forms of eruption are usually associated with impaired nerve influence; inclusively, they are widely known in Western Asia under the term “*bārās*,” and the most typical of them corresponds to the “*leuke*” of classical

Greek writers. In certain characters *bārās* may, I think, be compared with the "lepra" of the present day (Willan), only that the "scaly" feature is wanting, because in warm climates conditions are not favorable to the accumulation of dried epithelium on the skin, and it might be termed "*lepra leprosa*" in English nosology.

2. Destruction of the *cutaneous nerves*, this is the characteristic lesion of the disease.

3. Hence result the marks presented by lepers—large pale or dark blotches on the skin; anæsthesia of the extremities and trunk, with subsequent wasting, distortion or partial loss of the hands and feet, the muscular power, however, remaining more or less intact.

If "tubercles" predominate there ensue a well-known disfigurement of the visage, and scattered swellings in the integument, as well as on the tongue and palate, and in the larynx; commonly, anæsthesia and pale patches coexist with these "tubercles."

Subsequent changes are slow in progress, and are indicative of malnutrition of the body, both local and general, and hence susceptibility to corresponding hurtful influences.

The only infallible signs of leprosy, in my opinion, are one or other of the above marks. I know of no truly characteristic prodromata.

It will be observed that no reference is here made to symptoms of *visceral lesion*; indeed, there appear to be none peculiar, and while it is true that lepers die bearing the mark of their disease upon them, this event does not take place at any one period of the malady, or at any particular age of the patient, or in any uniform manner; in short, death occurs from simple exhaustion or from chronic dysentery or diarrhœa, or other intercurrent affection, induced by the want and exposure which are too often the lot of the miserable leper.

4. *Morbid anatomy and histology.*—The structural changes observed are due to exudation or deposit in the skin and nerve-trunks of a firm, translucent, colourless, or pale reddish material, which may be distinguished

by the borrowed terms "hyalin fibroid" and "hyalin granular."

As regards the skin, conjunctiva, and adjoining mucous membrane of the mouth, this deposit (here hyalin granular) first appears within or immediately beneath the cutis or mucous membrane; the hairs and glands are more or less involved, the functions of the nerves being impaired; those papillæ containing tactile corpuscles are early affected, and I have also found the pale muscular bundles with their nuclei in a state of fatty degeneration. The blood-vessels are not particularly altered, and ulceration of the "tubercles" is not common, except in the mouth and larynx.

As regards the nerves, this deposit (hyalin fibroid) first appears between the individual nerve-tubules and within their common envelope, *i. e.* the neurilemma of the funiculus; the outer sheath of connective tissue is hardly changed. By accumulation of the new material the nerve-tubes are separated, compressed, emptied, and eventually destroyed.

The microscopic characters of this leprous deposit favour the view of its being an exudation capable of a low grade of development. It is true that it first appears in localities occupied by connective tissue; this is certainly the case in the skin, and probably so in the nerves, for, although I found it hard to say whether or not any intertubular substance normally exists in ordinary nerve-bundles, yet their delicate neurilemma and the primitive sheaths contain cells or nuclei, whence proliferation might start, and I have sometimes found the new material cellular rather than fibroid in character. Still, there is an abundant neoplasm whose source appears exudative. At a subsequent stage degeneration, fatty or even calcareous, may take place.

There are some minute differences in the appearance of the deposit as it is found respectively in the skin and nerves, which need not now be insisted on.* (See Plate IX.)

* Full details of the symptoms and morbid anatomy of leprosy are contained in my article published in the 'Transactions of the Bombay Medical and Physical Society,' new series, vol. viii, 1862.

In sixteen autopsies, carefully performed, no trace was noticed of deposit in the muscles, bones, or in any of the viscera; the brain and spinal cord were wholly free from deposit.

I should add that the inguinal glands (superficial) may be enlarged, the nipples may become nodular in both sexes, and I have seen the testes both enlarged and wasted; yet not one of these circumstances, when thoroughly sifted, appeared to really impugn the statement that the leprous disease is, in its manifestations, limited to the cutaneous system.

5. *General characters and prevalence.*—True leprosy prevails in all parts of the Bombay Presidency, though commonest of all on the sea coast at about 18° N. lat. (1 leper in 430 inhabitants), yet it is almost as frequent (1 in 550) in an inland district elevated 2000 feet, with no large rivers running through it; in short, the disease is found under all climatic conditions, whether of soil, vegetation, temperature, or rain-fall; its intensity has no ascertained relation to the sub-varieties of climate in Western India, and if it have to geographical conditions, this is only because they are connected with racial distribution.*

The disease affects all classes of the community, varying in proportions roughly estimated at 1 leper in 400 of population (Kolis and Mahrathas), to 1 in 2000 (Parsees); also both sexes, but males as 4·38 to females 1; it commences at all ages, but oftenest at 20—40 years in men, or somewhat earlier in women; it does not greatly shorten life. It spares no rank, and is not regulated in frequency by affluence or penury, and, in short, on wider review, it appears to prevail independently of such influences as social status, habit, customs, or diet.

The distribution of leprosy in Western India is, however, I opine, connected with that of the races of men belonging

* Full details of the characters and prevalence of leprosy in the Bombay Presidency, based on official returns, will be found in the 'Transactions of the Bombay Medical and Physical Society,' new series, vol. xi, 1871.

to the population. Thus, the aborigines and their existing descendants (including Mahrathas) seem more infested by it than are the higher castes (or Aryans); later invaders, as Arabs, Africans, and Jews, have brought the disease with them. The Portuguese half-castes are affected in full proportion.

One prime feature of the disease claims special notice, namely, its capacity of transmission in a latent form (the so-called innate predisposition) from either parent to their offspring. Upwards of one fifth of all lepers (8220) actually acknowledge such origin of their disease; thus, of 1564 instances, heredity in the direct line was named in 64·2 per cent. (the father being mentioned by 43·8 per cent.); through the collateral line (uncle, &c.) in 14·5 per cent., or as often as through the mother; while 21·3 per cent. had brothers or sisters affected. "Atavism" or reversion is not unfrequent.

Lastly, since, through the universal and long-prevalent influence of caste distinctions, the people of India are subdivided into sections, large and small, between whom no intermarriage is permitted, there has resulted a state of kinship, however at times remote, which cannot but have had, in conjunction with force of heritage, very decided influence in maintaining or even extending among them a leprous taint; and it is, I think, to the combination of racial proclivity, heredity, and concentration through caste restrictions, that the source, long persistence, and general prevalence of leprosy in Western India should be attributed.

6. *Seat, nature, and causes of the leprous disease.*—The following conclusions seem deducible from collation of orderly arranged data.

1. *Seat of leprosy.*—The defect constituting this disease involves the constitution, inasmuch as it is transmissible in a latent form to offspring; but with respect to its outward manifestation it is restricted to certain tissues of the integument or cutaneous system.

Evidence to this effect is both negative and positive, and may thus be summarised :—First, in sixteen unselected autopsies no uniform morbid change was observed in any of the great cavities or their contents ; the blood itself, so far as examined, varied in appearance, and the incidental character of the cause of death was sufficiently apparent. I have lately reconsidered the point, and am still of opinion that there is at present no positive evidence that leprosy, even in its worst form, involves the deeper-seated structures of the body.

Again, it is not every tissue of the integument which is directly implicated, but, as before stated, first the nerves, next the cutis ; and the nerve-affection I hold to be pre-eminently the more characteristic. Thus, both “ tubercles ” and “ eruption ” are invariably associated with nerve lesion, while this latter may, for a time at least, exist alone. By repeated dissections I have ascertained that so many of the cutaneous nerves are actually diseased as to render the assertion credible that none are not liable to become affected.

Very noteworthy, too, is the fact that these nerves—such as the branches of the fifth pair on the face, of the cervical plexus to the ear, &c., of the brachial plexus and intercostal to the upper extremity, of the dorsal nerves, and of the lumbar and sacral plexuses to the lower extremities—are all diseased beyond that spot in the deep fascia of the muscles at which they become strictly cutaneous, or, in other words, only in that part of their course in more immediate relation with the skin, and they are seldom altered except by subsequent wasting in the deep-seated part of their course. I never detected any constriction at the perforation in the fascia which could mechanically account for this marked limitation of disease, so significant in its meaning.

But sooner or later the deeper-seated main nerve-trunks of compound function become more or less diseased, and at first sight this might seem an objection to the view propounded. Let it, however, be noted that the nerves, *e.g.* the

ulnar at the elbow and wrist, the median at the wrist, the popliteal in the ham, the posterior tibial at the ankle—are earliest and most, if not alone, affected where in their course they approach nearest to the skin, and where, one might hence almost infer, some irritative influence reached them. It is true that the spots I have mentioned being near to joints, the nerves are there exposed to repeated traction during movements of the limbs, and that such traction, entailing pressure, may be sufficiently irritative to induce leprous deposit; but in many cases it will be found that there is a direct continuity between the affected main trunk and its altered cutaneous branches, which indicates extension of disease from the latter to the former. It should be specially noted that not every part of the larger trunks in these instances is impaired, since motor paralysis is rarely present to any extent, even in the worst cases of leprosy; and the inference is therefore plain, namely, that it is the sensory element of these compound nerves which alone is implicated.

I would here remark that, in my estimation, “trophic” or nutritive nerve-tubules are commonly associated with those termed “sensory;” and I will add equally explicitly my opinion that the process of nutrition may be directly affected by nerve-influence: the grounds of these statements are recorded elsewhere.

It may be urged that in the so-called “tubercular” leprosy the nerve affection is of very subordinate importance. Certainly it would seem as if the force of the disease, then I believe at its greatest, were in this case expended on the skin; yet without pressing mere argument I must observe that even in tubercular leprosy (which is comparatively rare in Western India and adjoining countries), the ordinary nerve-disease is well marked, as is proved by the dissection recorded in my first paper, as well as by those of the fatal cases of mixed tubercular and anæsthetic forms of the disease.

I have, too, been impressed by the fact that the seat of the tubercles on the face is just where the cutaneous branches

of the fifth pair emerge and pass onwards ; notable is this with reference to the first division, or supra-orbital nerve.

Again, I have so repeatedly found association of tubercular enlargement of the ear and disease of the great auricular branch of the cervical plexus, that I should be disposed to make this instance a stand-point for discussion ; the question being whether the phenomena are cotemporary or consecutive. Without prejudging, I think there are good grounds for believing in the priority and even causative precedence of the nerve-affection ; nor is there any error in assuming that impaired nerve-influence might dispose to leper deposit in the skin.

As respects the characteristic eruption known as "Baras," there are reasons equally or even more forcible for connecting it with the coexisting nerve-disease, but their repetition in this place is not needed.

Thus the characteristic nerve-lesion of leprosy appears amply competent to explain all the more serious symptoms of the disease—the loss of feeling, shrinking, drying and coldness of the skin ; the wasting and final disappearance of the digits, or even next segments, of the extremities. There is, indeed, such a close correspondence between the areas thus changed, and those of the nerves appertaining, that, having regard to the apparent sequence of symptoms, but one inference seems possible, to the exclusion of the idea that the ordinary tissues and the nerves are affected by a common change.

Finally, it should always be remembered that the effects of locally suspended nerve-influence greatly depend upon attendant circumstances. In India lepers belong for the most part to people of primitive habits and limited means ; they are therefore commonly without the appliances adapted to mitigate their complaint ; and what is worse, scores of them are yearly expelled their homes, or sent forth as wandering mendicants, being subject to such want and exposure as would be detrimental to even healthy people ; and hence most of their sufferings. On the other hand, I have known instances where with comforts and due care

the worst degrees of the disease have been so mitigated that life was prolonged for years and but little physical pain experienced.

II. *Nature of the disease.*

The proximate cause of leprosy appears to consist in a faulty condition of certain tissues of the integument—a defect, perhaps, of development, certainly a quality transmissible to offspring.

The existence of a dyscrasia or primary blood change seems hypothetical and even needless.

The nearest approach to evidence of such dyscrasia which I have witnessed in India is the stunted growth with arrested development of some young lepers, the victims of the tubercular or mixed tubercular and anæsthetic forms of the disease; but as these individuals were born and reared in dire poverty, and had been subjected since the outbreak of their complaint to additional privation and exposure, there already was apparent sufficient explanation of their miserable condition. In such cases, I may add, it is usual to see ulceration both of the digits and of the “tubercles” in various parts, especially in the mouth and larynx; internal ulceration and subsidence of the nose may also co-exist, which I have thought traceable to disease of the nasal branch of the first division of the fifth cranial nerve, and direct and more striking illustrations of similar correlations are recorded in my dissections.

Occasionally the urine is albuminous, with other signs of degeneration of the kidneys, but since I have not found in the renal organs a leprous deposit, these instances strictly have the force of coincidence only, and are not evidence of a dyscrasia peculiar to the disease under notice.

In the absence of more positive data, reasonings from analogy, *e.g.*, of leprosy with syphilis, strumous affections, &c., need not be entered on here; it may, however, be granted that conclusions negatively founded can be but provisional.

III. *Etiology.*

Of the numerous so-called causes of Leprosy the following alone need be noticed here: an inherited predisposition; contagion and inoculation; endemic influences.

Briefly, and with respect to experience in India, I am of opinion that heredity is the common cause of the complaint. This subject has been already referred to, but as more particularly noteworthy should be considered the fact that the inherited disease is identical with that not known to be derived; and it is from no desire of resorting to the obscurity yet enveloping the subject of heritage in disease that I am disposed to hold this fact as supreme.

Respecting contagion or inoculation, the evidence of crucial test is necessarily wanting; hence opinions will vary according to degrees of accuracy in available information, and according to the felt cogency of argument. In my Report based upon returns of all known lepers in the Bombay Presidency, the instances of married couples who are lepers are discussed, and it is shown that no sound inference can be based upon them; it is also mentioned that while sixty-six widows had leper husbands, only eighteen widowers had leper wives; but here again the circumstances are such that no inference is sure. The rare cases in which the disease might be traced to possible contagion or inoculation were too few to allow of a general affirmative statement on this subject.

With regard to endemic influences the data from a single sphere of inquiry may be deemed defective; yet I know of no one feature of air, soil, or water which has certainly led to this disease. Europeans, both civil and military, inhabiting every part of Western India, often for long periods, are virtually never affected with leprosy. Exceptional instances are, indeed, so rare that, since liability to contagion is usually denied, one might resort to the supposition of latent taint.

The correlated prevalence of malaria with leprosy, not to

mention closer relationship, has not been established, and the same must be said of local peculiarities in diet, habits, and hygiene.

Admitting, however, the frequent presence of an innate predisposition to the disease, its development may be favoured by all causes leading to deterioration of health, such as an unhealthy climate, bad or insufficient food, neglected sanitation, social hardships and the like; whence the numerous agencies to which leprosy has been attributed as effect to a cause. The converse also holds good; lepers do seem to improve on change of climate, and it has been assumed that the disappearance of leprosy in Europe may be directly referred to improvement in the diet and general condition of the people; but on taking a wide review none of the external influences now named can be accepted as true causes in originating, or, conversely, in eradicating the disease.

Lastly, no evidence is forthcoming that in India, at least, a natural tendency of the disease to subside exists.

N O T E

ON THE

Segregation of Lepers in India.

By a nominal return, made in 1867, of all known lepers in British territory under the Bombay Presidency, it appears that in 10 only of the 16 districts, and exclusive of Sind, their number is upwards of 8000; in four districts, placed in juxtaposition, the names of 5309 lepers were registered—a number equal to 1 affected in 600 of the population, and in one or two of them the number of lepers was nearly as great as in the whole of Norway, according to a former estimate.

When the results of the recent general census of the Presidency are made known, more complete data will be at hand; and in the future it may be possible to ascertain whether or not leprosy is on the increase—a question to be answered affirmatively in certain British Colonies, and in Norway—but meanwhile sufficient is known to engage attention with a view to remedial measures.

It was recently affirmed by high authority that as a means of checking the progress of leprosy, the compulsory segregation of lepers was not to be recommended; and, *inter alia*, it was then advanced that the decline of leprosy in Europe is attributable chiefly to improvement in diet, as well as of general hygiene, identical results being predicated in India on similar grounds. Apparently the assumption that leprosy is not contagious led to this discountenance of leper asylums, and the necessity for consistently explaining the extinction of the disease in Europe during the middle ages probably led to this result being referred to improved hygiene.

Yet neither of these considerations is final. For although the view that leprosy can be propagated by contact may not be upheld by the majority of medical men in India, whose opinions are necessarily based on ordinary observation, yet all would probably admit that special and precise information is needed to thoroughly settle the question with respect to all stages and forms of the disease; facts, too, are slowly accumulating in other parts of the world which at least render plausible the assertion that the casual inoculation of leprosy matter is one actual means of spreading the complaint. But on other grounds the segregation of lepers seems most desirable, for in India, as long as diseased people are allowed to freely intermix with others, this scourge will be propagated by marriage and by intermarriage of the affected, and the morally bad effects on the people of permitting them to harbour in their midst miserable and often disgusting cripples are, whenever the number of such subjects is considerable, quite undeniable. Custom, among the middle classes, does not demand more than the lodg-

ment of these wretched objects apart in a pent-house or hut erected in the outskirts of the village, while the poorer classes expel their lepers of both sexes, thus adding to the army of mendicants, and otherwise diffusing much evil. On the grounds, therefore, both of humanity and of expediency does it appear desirable that leper asylums should be made recognised institutions, adapted to meet a wholly special need of the country.

Respecting the statement that improved hygiene has in some countries and in past ages led to the extinction of leprosy, the reasoning seems to be defective, for all civilised nations have, and do yet, put in force measures more or less strict of quarantine against lepers, and this with no dissent on the part of the community; and as regards the decline of leprosy in Europe till its extinction at the close of the fifteenth century, after a prevalence of 400 years, dating from its supposed introduction by Crusaders returning from the East, the most patent fact seems to be not that of a general improvement during this period in the diet and habits of the people—to which change, indeed, due influence must always be allowed—but rather that of the rigorous measures adopted for checking the progress of this new scourge. Thus, “Laws were enacted by almost all the princes and courts of Europe to arrest its diffusion amongst their subjects; the pope issued bulls with regard to the ecclesiastical separation and rights of the infected; a particular order of knighthood was instituted to watch over the sick, and leper hospitals or lazar-houses were everywhere instituted to receive the victims of the disease.” During the middle ages almost every large town in Great Britain had a leper hospital or village near it for the reception and separation of the diseased, and some cities were furnished with more than one. These hospitals were intended for the isolation of the infected, not for their cure; they were charitable and religious rather than medical institutions.

“In Great Britain, as on the Continent, those affected or supposed to be affected with leprosy were obliged to seclude

themselves from society or enter a leper hospital, both by general custom and usage and by direct legal enactments." . . . . It is not necessary to quote further from Simpson's account of leprosy; and without pressing mere argument, it cannot but be admitted that the utter ban under which lepers were put by law and custom had the greatest influence in checking and eventually eradicating their intolerable malady; it may be said that it was thus "stamped out."

Nowhere in the east does there appear ever to have existed such a machinery; and there the disease is probably as rife as ever, and certainly rendered more inveterate by this tolerance for centuries.

To mention the old harsh leper laws except with depreciation might not be acceptable; yet if the alternative to their partial imitation in India be the hope "that a marked change in the habits of the native population will ensue upon the increase of divers industries, the improved cultivation of the land, the less frequent recurrence of famines, and the consequent amelioration of their general condition from year to year, and that better food, better clothing, and better housing, with greater personal cleanliness, will lead to the abatement of leprosy, may be confidently anticipated," there can then be no such early prospect of this scourge being eradicated as might consistently be anticipated from unsparing employment of all the means which experience, both past and present, would indicate as the more efficient.

Assuming that practical measures are positively needed for the purposes of checking the progress of disease, relieving burdened poor, and removing from sight a wretched class of mendicants, three measures at least are open to adoption:—1. Strict segregation of all indigent lepers (as a preliminary measure) in fit houses or villages within the district to which they belong. 2nd. Disportation of the affected to a central, cool, and healthy locality. 3rd. The establishment of hospitals for the accommodation of lepers alone, should any plan of treatment be found to be strictly curative.

APPENDIX

TO THE

Preceding observations on the Pathology of Leprosy.

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1. It seems fit that reference be made to the views of Professor Virchow on this subject. These I have quite recently perused with much interest in the French translation of Virchow's work on the 'Pathology of Tumours,' vol. ii, p. 486 *et seq.*, 1869.

2. A chief point—namely, that of the constitutional nature of leprosy—Virchow regards as yet undetermined, although venturing on the statement that he is perfectly convinced that tumours of this kind (*i. e.* leprous tubercles) are to be met with in deeper-seated parts and giving, as evidence, the instance of a testis found to be the seat of such tubercles.

Now I, too, have found the testis enlarged in a diseased leper, but then the change was referrible to syphilitic disease. Nor can the implication of the superficial lymphatic glands, or the sub-mucous tissue of the tongue, palate, and larynx be regarded as different or better evidence of constitutional taint than the changes in the skin itself, and in the cutaneous nerves, which I am disposed to insist upon more than other previous writers, so far as my acquaintance with them extends.

Lastly, while it is true that the negative testimony afforded by the Bombay dissections can necessarily have but a certain value, yet in my opinion it is quite premature to decide that the deeper-seated organs are affected in leprosy, and this conviction is not shaken by the scanty counter-evidence hitherto adduced. Be it remarked that the appearances depicted in the oft-quoted 'Monograph' of

Danielssen and Boeck are not now insisted upon as characteristic of visceral lesion peculiar to leprosy ; on the whole, therefore, this disease resembles lupus rather than syphilis, and it is sufficient to concede that a constitutional form of leprosy may be by-and-by made out, as has been done with respect to syphilis, there being at present neither sign nor need of such revelation.

3. Believing that the facts accumulated in India are more numerous and of wider range than others before discussed, I have sought to give expression to the plain inferences derived from them. As regards the causes of leprosy, one must regard it as unproven that they are certainly either endemic and local climatic influences or dietetic faults. And respecting the supposition of Professor Virchow that there must be a special cause of leprosy, considering that the disease has now disappeared in the most complete manner from parts where it once prevailed, all that need be said is that the circumstance of its well-nigh total disappearance in Europe is well and fully explained (such is the view here advanced) by the utter exclusion from mixture with their fellows, to which lepers were subjected by law and custom, whence it became impossible that a tainted progeny should persist in the land. Even then the disease was not extinct until after the lapse of four or five centuries at the shortest ; and it has been well remarked that the last lingering traces of leprosy in a once infected locality will be found in groups of individuals connected together by family ties.

DESCRIPTION OF PLATE IX.

Microscopic Character of the Morbid Deposit in Leprosy.

FIG. 1.—Portion of a diseased *median nerve* removed at the autopsy of the case marked A. L. 3 (Anæsthetic Leprosy), in the author's first Memoir. $\times 350$ diameters.

a, a. Two nerve-tubules imbedded in the new material and greatly altered by its accumulation; sometimes they are emptied as it were by compression, and their wrinkled sheath alone remains; at others they are more irregularly affected, being dilated and contracted at intervals and have a corrugated aspect.

The new deposit is but scantily provided with nuclei; these vary somewhat in form, are delicately granular, and their long diameter may be $\frac{1}{2000}$ th in. or more. The addition of acetic acid does not cause this substance to swell. There is no evidence of elastic-tissue fibres. Here the appearance may be distinguished as "hyalin-fibroid."

FIG. 2.—Portion of *tumefied skin* from the left cheek. Case described as M. L. No. 1 (Mixed Leprosy, anæsthetic and tubercular), in the above Memoir. $\times 300$ diameters.

The new material (here "hyalin-granular") presents a homogeneous aspect, is disposed in layers, as would appear from the position of the nuclei or granular masses; these are of a yellowish colour, granular aspect, and very irregular form; in some cases are indications of a nucleus, but commonly the cellular character is not apparent. In isolated places the material seems to occupy the intervals between bundles of the connective tissue, as if resulting from effusion there. It is not so readily acted upon by acetic acid as is ordinary white fibrous tissue. *Æther* has little effect.

A portion of tumefied skin from the leg of the same case displayed a similar appearance, but the indications of free cells or nuclei in the new material were more evident, and these cells were sometimes of stellate form or branching into fibres; the granular masses were fewer.

a. Free cells. Diameter $\frac{1}{2000}$ th in. to $\frac{1}{1000}$ th in. The granular masses are usually of greater length than this.

Fig. 1.

Fig. 2.