

Contagion.

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CONTAGION.

THE WORD *contagion* is applied in pathology to the property and process by which, in certain cases of disease, the affected body or part causes disease like its own to arise in other bodies or other parts; and the Latin word *contagium* (*contagia*) is conveniently used to denote each such case the specific material, shown or presumed, in which the infective power ultimately resides.

The property of CONTAGIOUSNESS belongs to a very large number of the diseases which affect the human body. And in more than this direct way the property is of great interest to mankind. Contagiousness of disease is a fact not only for man, but apparently for all living nature; and the influence of contagion in spreading destructive diseases among *domestic animals*, and among those parts of the *vegetable kingdom* which contribute to the nourishment of man, is such as to make it of immense social importance that the laws of contagion should be well studied and understood. Further, just as contagion in the case of living bodies and their parts spreads disease from one to another, so, to an immense extent, in the case of certain matters which, though of organic origin, are *not living* it spreads various processes of decay. The so-called 'fermentations' which yield alcohol and vinegar, as well as that in which putrefaction consists, are contagious affections of the respective matters in which they occur: every cheesemonger knows that moulds of different kinds spread by inoculation, each in its own kind, from cheese to cheese; and if the Greek proverb 'grape mellow to grape' is true of the ripening fruit, the apple-loft gives analogous experiences of contagion among the fruit which is ripened.

The RATIONALE of the word 'contagion,' as now used, is that the property is understood to attach itself essentially to a material *contact*; not necessarily that, when infection is spread from individual to individual, the contact of the individuals must have been *immediate*; but that in all cases there must have been such passage of material from the one to the other, as was in itself at least a *mediate contact* between them. And similarly, in those very instructive illustrations of the process of contagion which are furnished within the limits of a single diseased body by the propagations of disease from part to part of it, we can in general easily see that infection passes from part to part, either in proportion as part touches part, or in proportion as the one receives from the other the outflow of lymph or blood or secretion.

The various SPECIFIC MATTERS which effect contagion in the living body, the respective 'contagia' of the given diseases, seem all to have in common this one characteristic: that in appropriate media (among which must evidently be counted any living bodily texture or fluid which they can infect) they show themselves capable of *self-multiplication*; and it is in virtue of this

property that, although at the moment of their entering the body they in general do not attract notice, either as objects of sense or as causes of bodily change, they gradually get to be recognisable in both of these respects. Now, the faculty of self-multiplication is eminently one of the characters which we call *vital*; and when it is said that all contagia are self-multiplying things, this is at least very strongly to suggest that perhaps all contagia are things endowed with life.

In order to any general consideration of the question thus suggested, contagia may conveniently (even if but provisionally) be distinguished as of two main CLASSES, differing, or at present seeming to differ, from each other in their mode of action on the organisms which they infect: one class, namely, that of *Parasites*; and the other class, that of the true or *Metabolic Contagia*. Of this separation, so far as present knowledge seems to justify it, the assumed grounds are: that each true Contagium, in proportion as it multiplies in the body, *transforms*, in a way which is specific to itself and is different from the ways of other contagia, the bodily material with which it has contact; while, on the contrary, the Parasite, however much it may grow or multiply in the body, produces no qualitative effects specific to itself, but only such effects as are of common kind to it and all other parasites—indications, namely, of its *mechanical intrusiveness* in the parts which it occupies, and sometimes of the *drain* which it makes on its host's general nutritive resources.

A.—Of PARASITES, in relation to processes of contagion, little needs be said in the present article. When an organism or part of it is, in greater or less amount, inhabited by other organisms, animal or vegetable, which subsist on it, or its food or refuse, it of course may be a centre of infection to other (if susceptible) bodies or parts, to which it can transmit live parasites or their germs or seeds: for, when this transmission takes place, growth and self-multiplication, as in a colony, are the natural results which have to be expected; and in proportion as these occur, the newly-infected body or part gradually gets to suffer, like the old, from those particular derangements which make the type of parasitic disease. Some parasitic diseases, especially some of those of the skin, spread actively by direct contagion in ordinary intercourse; as for instance, scabies by the migration of its acari, and porrigo (among children) by the spores of its microphyte; and the spreading of such diseases where they exist may of course be to any extent facilitated by aggregation of persons and uncleanness of personal habits. There are cases in which parasitic disease spreads from animal to animal only in proportion as the one feeds on the other, and eats it with parasites still living in it; or in proportion as live parasite-eggs or larvæ, discharged from the body of one animal, get conveyed with food (especially on raw herbage and in water) into the

bowels of another. Considerable epidemics of trichiniasis in the human subject have been traced, chiefly in Germany, to infection from the pig; in cases where pork, abounding with trichinæ, has been eaten, as sausage-meat or otherwise, in a raw or imperfectly-cooked state: and in Iceland the very great sufferings of the human subject and the cattle from echinococcus have been traced to the influence of the dogs in spreading contagion from the slaughter-house, where they eat hydatidised offal, to the kitchen-gardens and water-sources and pastures, where they discharge tape-worm eggs from their bowels. See PORRIGO, SCABIES, TRICHINA, HYDATID. &c.

The DISEASED STATES which consist in being colonised by parasites are diseases of indefinite duration, tending in some cases to indefinite increase. In cases where the disease consists in the presence of swarms of blood-sucking or otherwise exhausting animal parasites, symptoms of the blood-drain will of course gradually arise; but otherwise the parasite, whether animal or vegetable, operates only as a mechanical presence. Skin and mucous membrane will be irritated in their superficial layers, and in some cases more deeply, by the animal or vegetable parasites which breed on or in them, just as they might be by dead mechanical irritants: solid organs having cystic entozoa in them will in like manner show evidence of irritation by encapsulating the colonists; and the surrounding tissue will of course suffer compression and displacement in proportion as the colonisation (*e.g.* in case of echinococcus) is compact and massive. In the case of trichiniasis—but, in our ordinary experience, in no other—the multiplication of the parasites, the burrowing of their young, and the general diffusion of these in the body, are processes of such extreme activity that, if the quantity of contagium taken into the stomach has been large, the innumerable local irritations suffice to make a very acute fever; but even in this extreme case, the merely irritative type, though exaggerated, is essentially preserved.

As different sorts of animals are notoriously liable to different sorts of parasites, so, even among animals of one sort, as for instance in the human kind, the LIABILITY of different bodies to receive particular parasite-infections, does not seem to be quite equal for all. Especially, the vegetable parasites seem to have their affinities determined or modified by the general state of health of the recipient; and there are cases in which it looks as if there ran in particular family-lines (perhaps with some slight chemical idiosyncrasy) a special liability to particular intestinal worms. There, however, is no reason to believe that in regard of the more important animal parasites, as particularly of trichina and the tæniadæ, the susceptibility of individuals to attacks is other than universal and practically equal.

B.—The true or METABOLIC CONTAGIA (to which the rest of the present article will exclusively refer)—the contagia which, in their respective and specific ways, operate *transformingly* on the live bodily material which they affect, are perhaps the most important of all the incidental physical influences which concern mankind. Whether they may all, at some time hereafter, admit of being named, like the parasitic con-

tagia, in terms of biological classification, is a question which needs not in the first instance be raised; for meanwhile the identity of each separate true contagium is settled in experimental and clinical observation by the uniformity of the operation of each on any given animal body which it affects. Each of the diseases propagates itself in its own form in as exact identity, as if it were a species in zoology or botany; and in each such repetition of the disease there is a multiplication—always a large, and sometimes an inconceivably immense multiplication, of material which has the same infective property. Evidences innumerable to that effect are under daily clinical observation in this climate in instances of smallpox, measles, scarlatina, whooping-cough, enteric fever, mumps, typhus, syphilis, cowpox, diphtheria, erysipelas, hospital gangrene, purulent ophthalmia and gonorrhœa, venereal soft-chancres and phagedæna, &c.: for, barring fallacies, no man ever sees any one of those diseases produced by the contagium of any other of them; and any man who has before him a case of any of them can see that, however minute may have been the quantity of contagium by which the disease was started, the patient's diseased body (part or whole) yields for the time an indefinitely large supply of the specific agent. It is more or less habitual to some of the diseases that the infectedness of the patient is first made known to the observer by such *general pyrexia* as tells of change already far advanced in the circulating mass of blood; and it is only after this has shown itself, that other symptoms, adding themselves to the fever, complete the more or less complex type which establishes the identity of the disease. But in many of the diseases it may be the case (either naturally or as result of experimental infection) that the first, and in some diseases the main or even the only, effects of the contagion are *local changes*, passing where we can from the first observe them; and the broad facts of metabolic infection, as regards waste of bodily material with concurrent increase of contagium, are, in many such cases, among our most familiar experiences. Most instructive, too, are the facts of contagion which are to be learnt in the study of tubercle: the contagium, introducible either by tubercular and certain septic inoculations through the skin, or internally by the infective action of the milk or diseased organs of tubercular animals if taken as food; and the contagium, when introduced, gradually spreading as it multiplies, and as lymph and blood carry it from the first infection-spot to other organs which now will repeat the process. And similarly in cancer (though the primary disease is at present of unknown origin and cannot be created by experiment) the repetition of the primary disease in secondary and tertiary propagations in the body of the sufferer is one of the most striking of all evidences of contagion; because of the great number of structural types which pass under the name of cancer, and the fidelity with which each of them is reproduced in the organ to which the contagion extends. A further fact of contagion, deserving notice in the present context, is the local spread of certain of these processes by continuity of tissue; as, for instance, in the continuous extension of phagedæna or hospital-gangrene from

any centre of first inoculation, or of tubercular softening or cancer at the place where it begins: a mode of extension which indicates successive infective actions of matter on matter in spheres of ever-widening circumference;¹ and the like of which, but in rudimentary degree, may be traced in the areola of any acute inflammation.

In the physiology of the metabolic contagia no facts are more characteristic or more important than those which show the RELATIVENESS of particular contagia to PARTICULAR RECEPTIVITIES of body. First, and in intimate connexion, as would seem, with a *chemical electiveness* of action which will presently be imputed to contagia, there is the preference which some particular contagia (however introduced into the system) show for particular *organs* of the body; so that, by the exercise of this preference, there is given to each of the diseases its own set of clinical and anatomical characters. Compare, as instances in this point of view, the respective local affinities of smallpox, enteric fever, mumps, syphilis, hydrophobia, &c.—Secondly, it may be noted that, in regard to some of the contagia, different *persons*, and particularly persons of different *family-stocks*, show original differences of susceptibility; original, namely, as distinguished from others, hereafter to be mentioned, which are acquired; so that, for instance, the severity with which scarlatina or diphtheria will strike in particular families contrasts with a comparative mildness of the same disease in other families, or perhaps even with cases of apparently complete personal immunity under exposure to the particular danger: and recent researches have seemed to suggest as possible that, in the very wide differences of degree with which tubercular disease prevails in different families, an essential condition may be, that the families have widely different degrees of original predisposition towards some of the septic contagia.—Thirdly, there is the extremely suggestive fact with regard to many of our best-known febrilising contagia, that they run a course of *definite duration*, and that in this course, provided the patient do not die, all present, perhaps all future, *susceptibility to the particular contagium is utterly exhausted from the patient*; so that re-introduction of the same contagium will no more renew that patient's disease than yeast will excite a new alcoholic fermentation in any previously well-fermented bread or wine. The inference from this fact seems unavoidable, that each such contagium operates with a chemical distinctiveness of elective affinity on some special ingredient or ingredients of the body; and that exhausting this particular material in febrile process, which necessarily ends when the exhaustion is complete, is the bodily change which the contagium 'specifically' performs.—Of not all metabolic contagia, however, can it be said that their operation runs so definite and self-completing a course. For, first, there are particular *acute infections* which, as a rule, kill; either (as appears to be the case in splenic fever when affecting man) because of the extreme magnitude of the transforming process which the

contagium sets up, or else (as appears to be the case in hydrophobia) because the elective incidence of the contagium is on an organ indispensable to life; so that in such cases there is in fact hardly such an event as passing alive through the whole process of the disease. And secondly, there are the *contagious dyscrasias* which are clearly characterised by their tendency to indefinite duration: syphilis, which oftener than not relapses in successive outbreaks, and often as years pass invades the body more and more deeply, and may after all never during life be ended; and tubercle and cancer, which, with almost invariable persistence, will in general steadily advance month by month to infect more and more of the body till the process eventuates in death.

The transmission of various contagious diseases IN COMMUNITIES is of course greatly influenced, both in detail and in aggregate, by such differences of individual receptivity as were mentioned in the last section. Notably, as regards communities through which particular acute infections have had full run, fresh sparks of the contagium may find little or no fuel on which to act; and much new diffusion of the disease may not again be possible, till immigration, or births, or lapse of time operating in other ways, shall have reconstituted a susceptible population. And, given the susceptible population, circumstances of time and place are infinitely various (especially as regards quantity and quickness of personal or quasi-personal intercourse) in determining how far this population shall have particular contagia thrown in its way.

Also there are conditions, not primarily of a personal kind, which operate on a very large scale in determining the spread of some of the metabolic infections: giving to them respectively *at certain times*, in ways not hitherto understood, a *special increment of spreading-power*, and in some instances also *special malignity*: and thus enabling them respectively from time to time to come into comparative prominence in national life, and perhaps at once or successively in many different countries, in the form of so-called EPIDEMICS. Thus, it is matter of familiar knowledge that the fevers which are most habitual to this country, scarlatina, measles, smallpox, enteric fever, are of nothing like uniform prevalence,—that scarlatina, for instance, will be three times as fatal in one year as in another, and that smallpox is liable to even greater exacerbations: and it is known that temporary differences of this kind are not exclusively local,—that, for instance (to quote a late official report) 'the epidemic of smallpox which began in England towards the close of 1870 and terminated in the second quarter of 1873 was part of a general epidemic outbreak of that disease, of world-wide diffusion, marked wherever it occurred by an intensity and malignity unequalled by any previous epidemic of the disease within living memory.' The wider the survey which we take of epidemiology, the more certain it becomes to us, that, outside the conditions which are independently personal or local, there are *cosmical conditions* which have to be considered. Doubtless there are great epidemiological facts—such, for instance,

¹ Compare Tennyson's

'little pitted speck in garnered fruit,
Which, rotting inward, slowly moulders all.'

as the first spreading of smallpox to America, or in our own times the increasing frequency of Asiatic cholera in Europe, which may be ascribed to novel conditions of international intercourse: but there are others, equally great, to which apparently no such explanation can be applied. For what reason it is that cholera every few years has its definite fit of extension in India,—or why diphtheria, which scarcely had a place in history till it overran Europe in the 16th century, and which since then had been rarely spoken of, began again some twenty-odd years ago to be comparatively important in England,—or why the plague of the Levant has for the last two centuries been so unfamiliar to us,—or why the yellow fever of the Mississippi has in particular years raged furiously in parts of Europe,—or why our black-death of the 14th century, though apparently still surviving in India, has never but that once been in Europe,—or whither has gone our sweating-sickness of three centuries ago,—or whence have come the modern epidemics of cerebro-spinal meningitis: these, and many like questions, which cannot at present be answered, seem to be evidence enough that, in the making of epidemics, contagion and personal susceptibility may be factors in a partly *conditional* sense. Influences which are called 'atmospheric'—the various direct and indirect influences which attach to the normal succession and occasional abnormality of seasons, in respect of the insolation of our planet, and of the temperature and humidity of air and earth—are in general far too vaguely regarded as elements of interest in the present question, but are possible factors which no epidemiologist should omit from scientific consideration. For any definite knowledge which exists on the relation of particular conditions of season to the prevalence of particular epidemics, the reader is referred to the article *EPIDEMICS*, and to articles on the respective diseases.

In the *PASSAGE* of the metabolic contagia *FROM PERSON TO PERSON* various agencies may be instrumental,—bedding or clothing or towels which have been used by the sick, dirty hands, dirty instruments or other utensils, the washerwoman's basket, foul water-supply, stinking house-drains, contaminated milk or other food, the common atmosphere, &c.; but differences of that sort are only differences as to the *means by which such communication is established with a diseased body* as brings its products into relation with healthy persons; and the disengagement of *infectious products* from the bodies of the sick is pathologically the one influential fact. As regards the products which ought to be deemed infectious, the specially-diseased surfaces and organs of the patient, and the discharges and exhalations which they respectively yield, must always be regarded with chief suspicion; but suspicion, however much it may insist on them, must never disregard other sources of danger. Of some of the metabolic contagia we practically know, and of many of the others we may by analogy feel sure, that, when a given body is possessed by one of them, no product of that body can be warranted as safe not to convey the infection. Presumption against every part and product of the diseased body is by everyone readily admitted where

there are vehement general symptoms of disease: but it is important to know that not only in such febrile states, but even in states of chronic dyscrasy, and even at times when the dyscrasy may be giving no outward sign, the infected body may be variously infective. Thus, in regard to constitutional syphilis, it is certain that the mere utero-catarrhal discharge of the syphilitic woman, or the sperm of the syphilitic man, or the vaccine lymph of the syphilitic infant, may possibly contain the syphilitic contagium in full vigour, even at moments when the patient, who thus shows himself infective, has not on his own person any outward activity of syphilis. Similarly, in regard to tubercular disease, experiment has proved beyond question that the milk of animals suffering from tubercle will, if taken as food by other animals, infect them through the intestinal mucous membrane: and there are independent reasons for believing that the tubercular contagium (like the syphilitic) will at times during the dyscrasy be contained in the seminal fluid, and that men, tubercular perhaps only in some degree which is not immediately important to themselves, may by that secretion convey fatal infection to women with whom they have conjugal relations.¹ Regarding many of the metabolic contagia, conclusive evidence exists that, when they are in operation in pregnant women, the fetus will in general be infected by them; and this though the diseases (*e.g.* smallpox, cholera, syphilis) be of the most different pathological types: but with regard to pregnant animals affected with splenic fever it is noticeable that Brauell, in his extensive researches, found the blood of the fetus not to be infective.

In general, each contagium has its own favourite way or ways of entering the body; and these preferences are not only of speculative interest, as attaching to varieties of nature and natural habits among the contagia, but are of obvious practical importance as measures of the widely different degrees in which the different contagia are qualified to spread in communities. Thus, *inoculation at broken surfaces* of skin or mucous membrane has long been known as the ordinary mode by which the infections of syphilis, hydrophobia, splenic fever, cowpox, and farcy or glanders, get admission to the body; and our best knowledge of some other infectious diseases (notably of tubercle) has been derived from inoculations intentionally made with their contagia for purposes of study. While probably all infections which tend to be of general action on the body can be brought into action in that way, and while some infections are not known to pass by any other mode of transmission, there are many infections which spread freely from subject to subject by *atmospheric and dietetic communication*; and the meaning of these preferences is hitherto not fully known. It seems that some contagia are so acted upon by air and water, that they seldom or never reach the body in an effective state by those common means of communication,—some hardly, if at all, by water, and some not by air except with very close intercourse; and further, that, of contagia which reach the body in an effective state,

¹ See Dr. Weber, in *Clin. Soc. Trans.*, 1874.

some require, while others do not require, that an abnormal breach of surface shall give them special opportunity for taking hold. In some of the cases where a disease can be propagated in both ways,—i.e., certainly in smallpox, and apparently also in bovine pleuro-pneumonia, the artificially-inoculated disease tends to be much milder than the disease otherwise contracted; but pathologically it is difficult to conceive any essential difference between those different modes of contagion. It may be presumed that, in the modes which are not by true inoculation, acts which are comparable to inoculation take place on internal surfaces; that, for instance, when particles of scarlatina-contagium are caught in the tonsils, and inhaled into the bronchi, and swallowed into the stomach, they begin by penetrating the texture of the mucous membrane, and by thus effecting as real an inoculation, with regard to the blood, as that which art or accident provides in other cases through the punctured skin. That previous abnormal breach of surface by artificial puncture or otherwise is not necessary to allow the infection of mucous surfaces is illustrated in ophthalmia and gonorrhœa; where apparently no other condition has to be fulfilled than that a particle of the blennorrhagic contagium shall be deposited on the natural surface of the mucous membrane. It deserves notice that, while a considerable number of the worst diseases of the domestic animals admit of being communicated to man by artificial inoculation atmospheric communication seems to be very inapt, if not absolutely unable, to infect man with any one of them; and in this connection it may be of interest to remember that syphilis, one of the most familiar of human infections, but hitherto not traced to any brute ancestry, differs from our other current infections in requiring inoculation to transmit it.

When any metabolic contagium enters the animal body, it requires an *INTERVAL OF TIME*, and in most cases a considerable interval, before its morbid effects can become manifest even to skilled observation. The period of latency or so-called *INCUBATION* varies greatly in different cases. In hydrophobia it is very rarely less than of one month, is certainly often of several months, and is said to be sometimes of years. In syphilis the inoculated spot remains generally for at least a fortnight, and may remain even as much as five weeks, without any ostensible change; and the roseola of the general infection will not be seen till some weeks later, when generally at least three months will have elapsed since the first inoculation. In the acute eruptive fevers, when their contagium is transmitted by air, the first changes which ensue on infection are not external, and we cannot be sure what early internal changes may take place; but in smallpox, the fever (which is the first overt sign) does not attract notice till about the twelfth day after infection, nor the eruption till two days later; and in measles the incubation-time, though perhaps less uniform, seems to be little (if any) shorter than that of smallpox. The septic contagia and the contagium of splenic fever seem to be of particularly quick operation; but even the most virulent septic contagium, when without admixtures which tend to complicate its action,

will not begin sensibly to derange the infected animal till at least several hours after it has been inoculated. As regards the contagia last referred to, it is conceivable that the self-multiplication of the contagium in the form in which it proves fatal to life is a process which goes on continuously and uniformly from the moment of inoculation to the moment of death, and that the moment when signs of general derangement become manifest is the moment when this uniformly-advancing process has accumulated in the system a certain quantity of result:—but it does not seem easy to apply this explanation to the diseases of long incubatory period; and we can hardly conjecture what may be the latent processes—for instance of smallpox, during the first ten or more days after contagium has been received.

It is not yet possible to say, in any universal sense, with regard to the metabolic contagia, what is the *ESSENTIAL CONSTITUTION* of 'contagious matter,' or what the *INTIMATE NATURE* of the 'transforming power' which the particle of such matter exercises on the particles which it infects.—As regards the question of the *FORCE*, chemists, when they refer in general terms to the various acts which they designate *acts of fermentation*, allege that certain processes of change in certain sorts of organic matter induce characteristic changes in certain other sorts of organic matter, not by the common chemical way of double decomposition with reciprocally new combinations, but (so to speak) as a mere by-play or collateral vibration-effect of the chemical force which is in movement; and though language can hardly be more vague than this for any scientific purpose, it expresses clearly enough the conviction of experts that a certain great force in nature lies beyond their power even of definite nomenclature, much more of exact identification and measurement. In that most interesting, but most difficult and hitherto almost uninvestigated, branch of chemical dynamics, we are supposed to have our nearest clue to the scientific problems of the present subject-matter. It may be conceded that the 'contact-influences' which are dimly recognised as causing the fermentatory changes of dead organic matter have apparent analogues in many of the morbid influences of contagion: for the changes which chemists call 'fermentatory' are all catalytic or disintegrative of the organic compounds which they affect; and when living protoplasm is brought by contagion into processes of *characteristic decay*, the analogy seems sufficiently close to justify the word *zymotic* in the naming of the nature of the process. But it must not be forgotten that, among immediate effects of contagion in the living body, are cases wherein the process (so far as we can yet see) is primarily not *catalytic* or *disintegrative*, but, on the contrary, *anaplastic* or *con-structive*. Thus, when tubercle gives rise to tubercle, whether by secondary and tertiary infection in a single diseased body, or by infection from the sick to the healthy, each new tubercle which the contagion brings into being is a *growth-product* of the texture which bears it. And similarly, when the innumerable varieties of cancerous tumour propagate themselves by

contagion, each after its special type, in the bodies of the respective sufferers, it is growth, not disintegration, which we first see. It would seem that in those cases of anaplastic 'contact-influence' something far beyond the analogy of chemical fermentations must be involved; and, in view of some of them, the physiologist has to bethink himself of the analogy of that 'contact-influence' which becomes the mainspring of all normal growth and development, when the ovum receives spermatie impregnation.—As regards the ultimate ORGANIC CONSTITUTION of the several metabolic contagia—(each of them of course abstracted from accidental admixtures, and seen or conceived in the smallest and simplest units of quantity and quality in which its specific force can be embodied)—modern research seems more and more tending to show that the true unit of each metabolic contagium must either be, or must essentially include a *specific living organism, able to multiply its kind*. For with regard to those other contagia (as we may properly call them) which spread fermentatory processes in common external nature, and of which it is as clear as of the morbid contagia that they multiply themselves in proportion as they act, it seems to be established beyond reasonable doubt that the 'self-multiplication' of each of them as it acts is the infinite multiplication of a specific microphyte; and that this microphyte (acting apparently by means of a matter which it produces and from which it can be mechanically separated) is the essential originator of the fermentation.¹ This being the case in regard of those fermentations, it seems probable that the same is in substance true of the specific morbid changes which extrinsic contagia produce in the materials of the living body: probable, namely, that low, self-multiplying organic forms, specific in each case for the particular disease which is in question, are essential to each morbid poison; that the increase of each contagium as it acts is the characteristic self-multiplication of a *living thing*; and that *this* (however obscure may yet remain its mode of operation) is the *essential originator of change* in the affected materials of the diseased body. The fact that low organic forms of the sorts now spoken of have often, or generally, been seen in the morbid products and tissues of persons with zymotic disease, would not by itself be a proof, or nearly a proof, that the forms are causative of the morbid change: for obviously they might be mere attendants on the necrosis and decomposition of bodily material, availing themselves of the process (just as certain insects would) to feed and multiply: and in many of the cases in which micrococci have been seen in morbid material, no direct proof could be given that the meaning of their presence was more than that. There are, however, some cases in which

this proof has been completely established; and though such cases are at present but few, the significance of each of them in aid of the interpretation of other cases is of the highest importance. The researches of successive able observers in regard of the splenic fever of farm-stock, and those of Dr. Klein in regard of the 'pneumo-enteritis' (as he names it) of swine, have shown that in each of these cases the microphyte which attends the disease is botanically specific; that it and its progeny can be conducted through a series of artificial cultivations apart from the animal body; and that germs thus remotely descended from a first contagium will, if living animals be inoculated with them, breed in these animals the specific disease. It is equally well known that the organism (spirilla) which is found multiplying in the blood during the accesses of relapsing fever, is botanically specific; but in regard to this disease (which is not known to affect any other animal than man) experimental proof is still wanting that the microphyte, after long artificial cultivation, will be able to infect with the disease. Studies as complete as those which have been made in splenic fever and pneumo-enteritis will no doubt sooner or later be made in regard to many other of the diseases, but their progress will necessarily be slow; partly because the objects which have to be scrutinised, and to which specific characters have to be assigned, are so extremely minute, and often so similar among themselves, that none but very skilled and very patient microscopical observers are competent to pronounce on them; and partly again because the conditions of the case are such as to limit very closely the field within which the essential experimental observations can be made. Meanwhile, however, the two diseases, regarding which the larger knowledge has been obtained, must be regarded as highly suggestive in regard of other diseases of the same pathological group, and particularly as giving importance to fragments of evidence (not by themselves conclusive) which have been gathered of late years in studies of some of these other diseases. Eminently this is true of the large family of the septic infections—including on the one hand erysipelas and pyæmia with its congeners, and having on the other hand tuberculosis intimately associated with it; and almost equally it is true of enteric fever and cholera and diphtheria, and of the smallpox of man and beast. Thus, though it would be at least premature to say of these diseases that they certainly have as their contagia *microphytes respectively specific* to them, it seems at present not too much to say that probably such will be found the case; and if as much may not yet be said of many other diseases which are due to metabolic contagia, it must be remembered that the right lines of study relating to contagia in this point of view have not till within very recent times been opened.

Of the NATURAL HISTORY of the contagia, considered independently of the part which they play in the living body, there are hitherto only the beginnings of knowledge. The absolutely first origin of contagia may perhaps not be more within reach of scientific research than the absolutely first origin of dog or cat; but their nearer antecedents—the states out of which they come

¹ The doctrine to which the words in parenthesis refer (that the microphyte is not itself the ferment, but the producer and evolver of the ferment) tends to bring the case of these ferments into parallelism with that of the chylopoetic and other functional ferments which more highly organised creatures produce for the purposes of their own economy. In the latter case the distinction between the ferment-yielding live bodies (say certain gastric cells) and their not-live product (say pepsin) is already familiar.

when first about to act on the living body, and generally the variations which they and the common ferments exhibit under natural and artificial changes of circumstance, are within easy reach of investigation; and those humbler studies are likely to give very useful results. For some of our cases we seem to have an instructive analogy in the facts which Professor Mosler has put together in explanation of the blue-milk contagium of dairies: facts showing that the omnipresent *penicillium glaucum*, if its spores happen to alight in particular (morbid) sorts of milk, will operate distinctively on their casein as an anilin-making ferment, rendering the milk blue and poisonous, and imparting to each drop of it the power to infect with a like zymosis any normal milk to which it may be added.¹ In our own more special field, pathologists have already learnt that certain of the so-called 'morbid poisons'—the contagia of erysipelas, pyæmia and tuberculosis, are intimately related to the common ferment or ferments of *putrefaction*; and that the most vehement of these contagia can be developed by the artificial culture of successive transmissions in the living body from the comparatively mild contagium of any *common inflammatory process*.²

Two other directions suggest themselves as likely to lead to fields of useful observation and experiment. On the one hand, in *comparative pathology*, and with the tracing of contagion from animal to animal, there is the possibility that at last some lower and relatively worthless order of animals may be found the starting-ground of fatal infections for higher orders; and this, perhaps, by contagia which in their former relations are of mere inflammatory significance. On the other hand, in *geographical pathology*, and with the tracing of contagion from place to place, local centres of contagium-origination may possibly be found, in which the contagium, before it enters the animal body, will show itself an independent microphyte of the earth, first operating on the animal body as the essential force in a local malaria. Some of the worst pestilences known to the human race—yellow fever, cholera, perhaps plague, and also some of the diseases of cattle, have in their history facts which suggest that sort of interpretation: the supposition, namely, that certain microphytes are capable of thriving equally (though perhaps in different forms) either without or within the animal body; now fructifying in soil or water of appropriate quality, and now the self-multiplying contagium of a bodily disease. In regard to our own common ague-poison there seems every reason to suspect that its relation to soil is that of a microphyte; and though we know ague only as practically a non-contagious disease, we do not know that any little transfusion of blood from sick to healthy would not show it to be (in that way) communicable from person to person.

¹ Virch. Arch., vol. 43.

² See particularly Professor Sanderson's papers in successive yearly volumes of *Reports of the Medical Officer of the Privy Council* from 1868 to 1877. It concerns the second fact mentioned in the text to remember that apparently every 'common inflammatory process' includes more or less of textural changes which are necrotic and of septic tendency. See *Holmes's System of Surgery*, first edition, article 'Inflammation.'

It needs hardly be said that exact scientific knowledge of the contagia, and of their respective modes of operation, is of supreme importance to the PREVENTION OF DISEASE. With even such knowledge of them as already exists, diseases which have in past times been most murderous of mankind and the domestic animals can, if the knowledge be duly applied, be kept comparatively, or absolutely, in subjection; and the fact that at the present time fully a fifth part of the annual mortality of the population of England is due to epidemics of contagious disease is only because of the very imperfect application hitherto made of that knowledge. In the present article it is not necessary to state in detail the practice which ought to be adopted in the various different cases of infectious disease; but briefly it may be said that one principle is at the root of all such practice, whatever the disease to which it relates. This principle, which of course becomes more and more important in proportion as the infection is dangerous, and as the persons whom it would endanger are many, is the principle of *thoroughly effective separation* between the sick and the healthy: a separation, which, so far as the nature of the disease requires, must regard not only the personal presence of the sick, but equally all the various ways, direct and indirect, by which infective matters from that presence may pass into operation on others. Especially as regards the diseases which make serious epidemics, the principle of isolation is not carried into effect unless due care be taken to thoroughly disinfect in detail all infective discharges from the sick, and all clothing and bedding and towels and like things which such discharges may have imbued, and finally, as regards certain contagia, the rooms in which the cases have been treated; and in order to secure these objects, it is essential in all grave cases to make such nursing-arrangements and such arrangements of the sick-room (whether private or in hospital) that no retention or dissemination of infectious matters will escape notice. It is likewise essential that all who attend on the sick should be careful not to carry contagion to other persons; as they may but too easily do, particularly in scarlatina and in certain traumatic and puerperal infections, if they omit to take special precautions against the danger. See articles QUARANTINE, DISINFECTION, and PUBLIC HEALTH, and those on the special diseases.

The SOCIAL CONDITIONS through which, in our own country at the present time, the more fatal infectious diseases are enabled to acquire *epidemic diffusion* are chiefly such as the following:—that persons first sick in families and districts, instead of being isolated from the healthy, and treated with special regard to their powers of spreading infection, are often left to take their chance in all such respects; so that, especially in poor neighbourhoods, where houses are often in several holdings, and where always there is much intermingling of population, a first case, if not at once removed to a special establishment, will almost of necessity give occasion to many other cases to follow;—that persons with infectious disease, especially in cases of slight or incipient attack, and of incomplete recovery, mingle freely with others in work-places

and amusement-places of common resort, and, if children, especially in day-schools; and that such persons travel freely with other persons from place to place in public conveyances;—that often, on occasions when boarding-schools have infectious disease getting the ascendant in them, the schools are broken up for the time, and scholars, incubating or perhaps beginning to show infection, are sent away to their respective, perhaps distant, homes;—that keepers of lodging-houses often receive lodgers into rooms and beds which have recently been occupied by persons with infectious disease and have not been disinfected;—that persons in various branches of business relating to dress (male and female) and to furniture, if they happen to have infectious disease, such as scarlatina or smallpox, on their premises, probably often spread infection to their customers by previous carelessness as to the articles which they send home to them; and that laundries further illustrate this sort of danger by carelessness in regard to infected things which they receive to wash;—that purveyors of certain sorts of food, if they happen to have infectious disease on their premises, by carelessness spread infection to their customers;—that streams and wells with sewage and other filth escaping into them are most dangerous means of infection, especially as regards enteric fever and cholera; and that great purveyors of public water-supplies, so far as they use insufficient precautions to ensure the freedom of their water from such risks of infectious pollution, represent in this respect an enormous public danger;—that ill-conditioned sewers and house-drains, and cesspools receiving infectious matters, greatly contribute to disseminate contagia, often into houses in the same system of drainage, and often by leakage into wells. Of the dangers here enumerated, there is perhaps none against which the law of England does not purport in some degree to provide. At present, however, they all are, to an immense extent, left in uncontrolled operation; partly because the law is inadequate, and partly because local administrators of the law often give little care to the matter; but chiefly because that strong influence of national opinion which controls both law and administration cannot really be effective until the time when right knowledge of the subject shall be generally distributed among the people, and when the masses whom epidemics affect shall appreciate their own great interest in preventing them.

Whenever that time shall come, probably the public good will be seen to require, with regard to every serious infectious disease which is apt to become epidemic, that the PRINCIPLES which ought to be accepted in a really practical sense, and to be embodied in effective LAW, are somewhat as follows:—(1) that each case of such disease is a public danger, against which the public, as represented by its local sanitary authorities, is entitled to be warned by proper information; (2) that every man who in his own person, or in that of anyone under his charge, is the subject of such disease, or is in control of circumstances relating to it, is, in common duty towards his neighbours,

bound to take every care which he can against the spreading of the infection; that so far as would not of his own accord do this duty, neighbours ought to have ample and ready means of compelling him; and that he should be responsible for giving to the local sanitary authority proper notification of his case, in order that authority may, as far as needful, satisfy itself as to the sufficiency of his precautions; (3) that so far as he may from ignorance not understand the scope of his precautionary duties, may from poverty or other circumstances be unable to fulfil them, the common interest is to give him liberally out of the common stock such guidance and such effectual help as may be wanting; (4) that so far as he is voluntarily in default of his duty, he should not only be punishable by penalty as for an act of nuisance, but should be liable to pay pecuniary damages for whatever harm he occasions to others; that the various commercial undertakings which in certain contingencies may be specially instrumental in the spreading of infection—water companies, dairies, laundries, boarding-schools, lodging-houses, inns, &c., should respectively be subject to special rule and visitation in regard to the special dangers which they may occasion, and that the persons in authority in them should be held to strict account for whatever injury may be caused through neglect of rule; and finally, that every local sanitary authority should always have at command, for the use of its district, such hospital-accommodation for the sick, such means for their conveyance, such mortuaries, such disinfection-establishment, and generally such planned arrangements and skilled services as may, in case of need, suffice for all probable requirements of the district.

Persons who are imperfectly acquainted with the scientific and social facts relating to the present subject-matter, or who have never seriously considered them, may think it would be over-sanguine to expect any general recognition of principles so peremptory as the above may at first appear to them; but, if so thinking, they would perhaps have under-estimated the rapidity with which knowledge is increasing as to the common interests and mutual duties of mankind in respect of dangerous infectious disease. Fourteen years ago, when the so-called cattle-plague or steppe-murrain was imported afresh, as a long-forgotten disease, into this country, and was found to affect very large pecuniary interests, primarily of the chief landowners of the United Kingdom, but secondarily of other classes, an immensely valuable stimulus was given to the education of the country, and especially of its Legislature, in regard to the preventability of the infectious diseases. And the remarkable zeal and ability which have been shown, in providing adequate laws and admirable administrative arrangements against the diffusion of steppe-murrain and other infectious diseases of Farm-Stock, are not likely to be found permanently absent in relation to the interests of Human Life, when once the bearings of the subject shall have got to be popularly understood. JOHN SIMON.