A

SANITARY ENQUIRY

INTO THE PROBABLE CAUSES OF

YEARLY EPIDEMICS,

IN ENGLAND, AS OBSERVED AT

LEICESTER.

BY

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PREFACE.

It concerns all who regard the health of themselves, their families, and neighbours, to know something of the probable causes of yearly epidemics, and of the mode in which zymotic disease is diffused; for the very evident reasou that they may guard against attack.

The present sanitary enquiry is confined to Leicester, yet the principles discussed are equally applicable elsewhere; indeed it may be that there are few places to which they are unsuited.

I desire here to express my obligation to the nobility and gentry of the county and to the numerous friends in this town who have accorded me their approval and support. More especially am I indebted to the Rev. A. A. Isaacs, Vicar of Christ Church, for his cordial suggestions and assistance. And to the veteran sanitarian, George Godwin, Esq., F.R.S., under whose standard I have long been an earnest worker.

The subjects discussed in this little pamphlet although local, are yet general, and from the fact of their universality, no reflections are cast upon anyone; but what is endeavoured to be shown is, that the sanitary requirements of the present day, as taught us by science, are much in advance of those of twenty years since.

RICHARD WEAVER.

LEICESTER, 13TH JUNE, 1871.

Sanitary Enquiry, &c.

In common with many other towns, but perhaps more persistently than most of them, Leicester is subjected to periodical outbreaks of disease of a zymotic type, and it has been observed that diarrhœal epidemics occur yearly, and at much about the same periods within certain limits. Generally, however, these attacks are preceded by, or accompanied with other diseases of the same order--such as Small-pox, Measles, or Scarlatina. And especially during last summer and autumn, the inhabitants suffered severely from a double attack of Diarrhœa and Scarlatina.

At the period of greatest severity, it was stated in the local papers that as many as one thousand cases of Scarlatina were at that time under treatment. Be this, however, as it may, the Registrar General shows in his return that this combined epidemic swept off nearly 500 of the inhabitants during its continuance of from four to five months; and it is remarked that those deaths were chiefly confined to the infantile population. As an enquiry into the probable causes of these annual attacks, or however the causes tending to render the people more susceptible to the influence of disease, will—if properly applied—result in advantage, not alone to Leicester, but likewise to many other towns somewhat similarly situated, we purpose in this paper giving the pith of our investigation into this particular subject.

It has been noted during a series of years, and confirmed by the periodical mortality returns, that the health of the people of this district—so far as zymotic complaints are concerned, and especially Diarrhœa—is in the best condition as a rule during the months from February to April or May, although there are some exceptions that will be mentioned as we proceed. June shows a marked increase in the death rate, July still more so, whilst a maximum rate appears to be reached in August or September; from this time forward there is a gradual decline in the number of Diarrhœal deaths throughout the months from October to January.

Fever, that is prevalent all the year round, seems to follow a different law from the preceding complaint as to periods of greatest intensity. For instance, if in any particular month Diarrhœa is very persistent, as it was in August of 1868, in September 1869, and in August 1870, and there is a sudden decrease of deaths from this complaint in the succeeding month of each of these years as actually happened, then it is that the greatest developement of fever occurs, suddenly rising to a considerable height, again gradually declining through each successive month down to January or February. There is also usually an augmentation of fever cases about March or April, but in a less degree than the previous period just referred to. And it may be also stated that the fewest deaths from this cause happen in May and June.

The recent Scarlatina epidemic has followed a course again different from either of the first two mentioned disorders. It would appear to have become developed in December of 1869, when there were three deaths, the mortality of the prior eleven months amounting to only five deaths. During the first quarter of 1870, the deaths amounted to fourteen ; in the succeeding quarter of April, May, and June there was a sudden calm in the progress of the disease, the deaths amounting to three. July showed a slight increase, and August still higher. In the month of September the deaths rose quickly to thirty-one. The returns again show forty-five deaths in October, seventy-one in November, and eighty-two in December, resulting in a totality of 263 deaths within the year, of which close upon 200 occurred in the latter three months.

For these yearly epidemics various causes have been assigned, none of which, however, appear to us satisfactory. For instance, in respect to zymotic complaints generally, the late Medical Officer of Health of Leicester, in his annual report for 1866, states : " A plentiful supply of pure water is one of the sanitary measures *most* required in the prevention of cholera, as well as in all other zymotic diseases ; and the attention of our leading medical authorities, particularly in the metropolis, has been directed to this subject, and it is proved by them that according to the purity or impurity of the water has been to a great extent the amount of disease." " In Leicester the supply of water by the Waterworks Company is both ample and pure."

We may here pause to remark that so far as the first part of this question is concerned, we heartily agree with the reporter ; but as to the second part, we are entirely at variance with him, and affirm that the alleged supply is neither ample nor pure, as will be presently shown. The present Medical Officer of Health, in his report of 1867—an exceptionally favourable year—alluding to the few deaths from fever, states :— " Forty deaths from fever in a population of 88,500 inhabitants, speaks volumes as to the success which has attended the sewerage of the town and the attention which is always being paid to its sanitary condition; and a great deal must also be attributed to the supply of *pure water* supplied to many houses." After referring to the wells of the town being liable to contamination by leaky drains and privy cesspools, proceeds:—"For it is now well understood that both Typhoid Fever and Cholera are propagated as much from impure water contaminated by fœcal matter, and containing the germs of these diseases, as from aerial emanations from these agents." The worthy Doctor might also have included Diarrhœa, for it is well known to be produced by impure water, in proof of which we can adduce hundreds of cases. Perhaps the following may suffice:—

The Privy Council's Medical Officer, Dr. Seaton, in his report on Typhoid Fever and Diarrhœa, at Page Green, Tottenham, in 1866, states in allusion to the water supply:—"The way in which people go on unconsciously imbibing Fever and Diarrhœa from such wells as these, is so aptly illustrated by the occurrences at Caines Terrace." * * * "At the five houses of which the terrace consists, all derive their water from two or three surface wells. In the one (No. 5) from which the water was taken for analysis, (described by Dr. Miller as being from sewage infiltration quite unfit for dietetic purposes), Mr. Gaffney has lived for three years; his family consisting of four had all *Diarrhœa* soon after they came." Speaking of the adjoinging house, the reporter says,: "In May, 1865, the present occupant, Mrs. Slack, came; she, her son, and her daughter (the only permanent inmates) had *Diarrhœa* immediately on their coming; the lodgers she has received have each as they came successively had *Diarrhœa*."

"Mrs. Barnes has lived in the next house for two years. They are four in family, and for the first six months of their residence they had nothing but *Fever and Diarrhœa*; lately they have begun to take lodgers, they have had two sets, and each set has had *Diarrhœa*." Speaking of the remaining houses, Dr. Seaton says:—"Of the present occupants, the family residing in one of them, five in number, have all suffered from *Diarrhœa* since they came." "The family residing in the other, and three in number, have not suffered in any way, *but this family boil first all the water which they use for drinking*."

This gentleman concludes his report by showing that "the conclusion appears to me irresistable that the fever and illness (Diarrhœa) at Page Green have been mainly kept up by the use of impure water for drinking."

We think it very conclusive indeed, and call attention to the immunity from attack of the particular family in which the drinking water was boiled, an immunity that we know extends to thousands of instances. Our enquiries into the philosophy of boiling water tend to show a treble action—Firstly—The effect of a boiling temperature is probably to destroy the vitality of the germs of disease contained in the water, or to drive them off with the steam, for they are believed to be very light and volatile.

Secondly—The temperature of steam is sufficient to dissociate the putrid volatile organic bases from the non-putrid substances, and it is due in a great measure to this putrid matter dissolved in the water that renders such water unwholesome for potable usage; the other organic matter which has not arrived at a putrid condition being comparatively innocuous for the moment.

Thirdly—Nearly all natural waters contain Salts of Lime and Magnesia in solution, generally in the condition of Calcic and Magnesic Carbonates—perhaps better understood as Carbonate of Lime and Carbonate of Magnesia—which are dissolved in the water by Carbonic Anhydride, also known as Carbonic Acid gas. Now the affinity between the gas, the water, and the Carbonates is weak, so that when the whole is raised to the temperature of ebulition—as for instance in a tea kettle—the acid gas is gradually driven off, when there remains insufficient for solution of the Carbonates, and these are thrown down or precipitated as a fine powder. The Carbonates—that is the neutral Carbonates—are practically insoluble in water, the particles aggregate upon the sides and bottom of the vessel caking into a hard coherent mass, and is commonly known as the scale, although sometimes it is of a spongy character when sulphates are present.

Now in the act of precipitation the lime and magnesia likewise carry down with them some portion of the organic matter, and this organic matter for our present purpose must be understood as existing in two distinct conditions, viz., in mechanical suspension, hence visible to the eye, and in chemical solution, therefore invisible to the eye. Such portion of the matter suspended falls mechanically, becoming entangled in the heavier powdery crystals of the carbonates.

Some part of the organic matter existing in solution we believe to be likewise carried down by the carbonates, yet after a different mode to the other. In this instance, we take it, combinations occur between the organic matter and the carbonates, true salts resulting at the moment of freedom from solution.

We wish, moreover, to fully impress upon the reader that that part of the impurity of water expelled by boiling during the first ten or fifteen minutes is much more hurtful than that which remains, hence it is a good practice to boil all water of a doubtful quality purposed as a beverage; and we are inclined to include all in this category, respecting which we are not absolutely certain from actual competent chemical examination and enquiry into its source.

The habit of employing boiled water for dietetic purposes is of considerable practice and presumable antiquity, amongst those who are frequently considered of less intelligence than the average of English people.

By way of illustration may be mentioned the inhabitants of many parts of India, certain tribes of North American Indians, and we are further informed, by native Africans of swampy districts. Coming nearer home it is practised by the boatmen on our inland canals. And certainly this is a custom that may be profitably extended.

Putrid organic substances, particularly of animal origin, are known to be exceedingly deleterious when conveyed into the human system even in minute quantity and irrespective of the mode of conveyance, whether by the air that is breathed, water drunk, and the food consumed, or whether introduced directly into the blood through external wounds.

Leicester enjoys peculiar ideas on the causes of its annual diarrhœal epidemics. At the time of a most severe attack, in the autumn of 1868, the Registrar General threw out a broad hint for investigation, by saying that there must exist conditions in Leicester exceptionally favourable to the diffusion of Diarrhœa.

In answer to this challenge, a committee of the Local Board reported that the main causes of the special Diarrhœa mortality were the existence of open privy cesspits in the town, and to the fact of many dwellings being placed upon a damp subsoil; also to the use of impure water, and to domestic ignorance and neglect. With this resolution the responsible officer did not entirely agree; and believed that summer Diarrhœa did *not* arise from zymotic causes. On the contrary, he believed that *simple heat* is the cause of summer Diarrhœa in this country, and in the strong and robust it yields easily to treatment and diet, and that in the children it runs a different and a longer course, and the weak succumb.

That to account for the greater mortality in some towns than in others, the situation and the vigour of the inhabitants are to be considered.

He further "finds it impossible to assent to the theory that a large mortality from Diarrhœa is an evidence of the insanitary state of the town where it has taken place."

Leicester is happy in knowing that the increased number of deaths from Diarrhœa can be fully accounted for, without the hypothesis of a specific cause as generating the disease (vide Officer of Health's report of 1867). It is here noted that Dr. Buchannan observes a great increase in the deaths from Diarrhœa in Leicester since the sanitary works were completed. These operations, be it understood, included sewerage and waterworks.

It is contended that "the increase is not due to any sanitary defects in the town itself, *as obvious* from the acknowledged absence of these defects, and it is proved in other ways, and by a diminution of zymotic diseases generally." We wish at this stage to note that such *obviousness* is not apparent, and deny the absence of defects within and without the town.

In this same report, "It is not denied for a moment when Diarrhœa prevails extensively among adults and persons of mature age, as well as children, that it probably does arise in many instances from sanitary defects ; but that is not the case in Leicester."

And pray why not the case in Leicester? Whence this immunity to a specific cause that is admitted *may* exist elsewhere, and yet not here? How are these increasing yearly Diarrhœal epidemics to be accounted for? The medical officer tells us, "Reference will show that in Leicester at all events it is essentially a disease of children and season, that of 209 deaths, only twenty-one occurred above two years of age ; the deaths below that period amounting to 188, and almost all occurred in the month of September (!) That the deaths from Diarrhœa among adults and even old people, are at *any* season exceptionally small ; and this fact proves most *convincingly* the satisfactory state of the town in a sanitary point of view, instead of the reverse."

On this point we differ from the writer very materially, and maintain it is *convincingly* unsatisfactory that 188 infantile deaths should occur in the short space of about one month!

He "believes that the increase in the deaths from Diarrhœa will be found to depend—in addition to causes first stated—more upon the increase of manufactures, and consequent diversion of a great number of mothers from the congenial occupation of nursing their own children to manufacturing labours, than to any other special cause. ; the natural result of this unnatural proceeding being that the children are fed upon food unsuited to them, that they manifest the pain and injury to their health which it causes by their constant fretfulness and crying, and to sooth the excitement are dosed with 'Godfrey' or laudanum to keep them quiet."

"Can we wonder that these pallid, emaciated children thus treated—the tone and natural functions of whose digestive organs are utterly destroyed—fall victims to Diarrhœa, easily set up in the increased languor of the system, produced by the heats of autumn days, followed by the chills of autumn nights; and that in such subjects the most judicious medical treatment is unavailing."

This being put in the interrogative, we answer there has been more than enough of fencing the question on the part of the authorities of Leicester, and it is high time for the people to grapple with the cause of these yearly epidemics that affect the whole population, and sweep off hundreds of its infants to very premature graves. A paltry saving of a couple of thousand pounds to the Borough rates, is no palliation for the suffering and sorrow developed in thousands of homes! Those who are responsible for the health and government of this town have a terrible responsibility resting upon them in respect of these outbreaks, and for their laches in not stamping out, or at least ameliorating the conditions essential for their prevalence.

Nay, it is, perhaps, criminal as concerns the suffering and unnecessary deaths of the people under their government, and uncommercial as regards the pecuniary aspect; for where can be the gain in a yearly moiety of surplus profits from the Waterworks Company, amounting to about £2000, when there is a direct money loss to the community at large of at least ten times this sum, from the increased funeral and medicinal expenses. The loss of time incurred from inability to work and transact business, due to the prevalent Diarrhœa, afflicting probably more or less half the population, even for the moment leaving aside the other zymotic occasional attacks?

Long consideration and patient research into the subject of this pamphlet prove that the yearly attacks are due to causes that will be presently mentioned, and that such attacks are preventable. When having pointed out the same, it will remain for the people of Leicester, and independently, to continue more minutely and follow up the investigations here broadly conducted by us.

It is for them to determine how long they will so severely suffer from such attacks, and when the same shall terminate; for we unhesitatingly affirm that the remedy lies to a great extent within their own hands. In common with other Sanitarians, and as long has been shown, we believe many types of human disease are produced by known specific causes, and that these can be by suitable means greatly ameliorated, if not entirely prevented.

In sporadic and epidemic attacks the causes are not always traced, because sufficiently diligent search is not made; or as often happens, there is a false timidity in local government officers to speak out for fear of consequences where there are so many, and generally powerful interests, whilst those whom they immediately serve are directly concerned in such interests. It not infrequently arises from an idea that matters cannot be mended, that they may aright themselves in time, and so it is useless upsetting the public equanimity. Also coupled with an apathy on the part of said public, who fail to comprehend cause and effect. All of which reasons, whether arising from absolute ignorance or a suppression of knowledge, tend greatly to the disadvantage of the bulk of the people, and as such are reprehensible.

In the early stage of this enquiry some two or three years ago, it was considered probable the causes of diarrhœal epidemics lay within the limits of the town of Leicester itself, for it was represented that the public water supply was of undoubted good quality.

This theory, however, was gradually shaken, for it was noted that the diarrhœal complaint was usually prevalent over the whole town; and not more so—indeed at times less—in crowded, imperfectly ventilated localities, often supplied with water from surface wells; but there were exceptions in this from causes clearly understood at the time.

During the annual diarrhœal attack of 1869, in one week there were thirty-one deaths from this complaint, and it is observed that all were under medical treatment excepting two attended by a medical Botanist. Out of these thirty-one cases, twenty-four of the houses were supplied with water from the Waterworks taps, and the remaining seven cases were supplied from wells. It is estimated that about one-third of the population are supplied from surface wells, the water of a great many is of doubtful quality, whilst some are notoriously bad. Yet, notwithstanding this, it is remarkable there were comparatively so few deaths amongst the consumers of well waters. This is but one instance out of many. Observation shows that the prevalence of diseases vary as the rainfall; some, like diarrhœa, abating with heavy rains, whilst fevers become intensified. Repeated chemical examination of the public water supply reveals the fact of its varying quality. Generally in the spring of the year, in April or May, is the period of its maximum purity, the time of least contamination from sewage and animal organic matter, and even then it is not a pure and wholesome water. As the year advances the quality decreases, the minimum condition of purity is reached about August or September, by which time, particularly in dry seasons, the water is but little better than diluted and filtered sewage. The maximum of impurity being reached, a reaction sets in, when the water gradually improves in quality throughout the winter months. Thus goes on the same old thing from year to year with little variation, and such as there is coincides with the rainfall. Gradually in the course of examination this became evident, that the quality of the water varied as the rainfall; there is, in fact, a concurrence between them, and as previously stated, there is likewise a concurrence between rainfall and disease. These facts being noted, it became necessary to look a little more closely into the antecedents of the water that is supplied to the people of Leicester, and to determine the grounds of varying quality, and the source of organic and sewage pollution.

The reservoir, with an area of about eighty acres, and gathering grounds comprising some 2700 acres of cultivated country, and over which are spread numerous villages, is situated at Thornton, about ten miles to the west of Leicester. Two small streams, known as the Markfield and Thornton brooks, supply the reservoir, these conveying in time of flood considerable volumes of water; at other times the water is of meagre quantity. The village of Thornton lies abreast of the reservoir, on the apex of a ridge at an elevation of a hundred feet or so about it, in a very insanitary condition, abounding with cesspools, stagnant sewage, defective drains, fever and diarrhœa, together with a polluted water supply derived from the village of Bagworth, a mile away. The greater portion of this drainage decends the hill side towards the reservoir at the base, conveyed in pipes terminating in open ditches, or upon the greensward, whence, beyond doubt, it mingles with the waters of the reservoir. A few yards from the reservoir on the rising slope of the hill is the church and graveyard of Thornton, where are many hundreds of interments; no doubt its drainage, following the law of gravitation, decends to the reservoir beneath, as likewise do the contents of the foul open sewer running by the east wall of the churchyard.

These little streams, and their smaller feeders, run at the bases of several other villages such as Stanton-under-Bardon, Shaw Lane, and the considerable village of Markfield (whose population numbers more than one thousand persons in this latter village alone); presumably much of the sewage and graveyard drainage of these insanitary places descends into the brooks. Nay, no doubt exists, for we have direct evidence in some instances that the sources of some of the feeders are the public sewers of these elevated villages; notably in the case of Markfield, as we bear witness. Likewise on the banks of the brooks the often loathsome drainage of farm-yards and cottages, with their attendant necessaries, runs directly into the streams.

The various forms of zymotic disease in these villages are typhus, enteric, and scarlatina, whilst diarrhœa and low kinds of fever appear to be permanent residents. The general sanitary arrangements are not good; the water derived from surface wells sunk in their midst, is at least in some instances considerably charged with sewage.

We entered a house at Stanton and enquired for the mother of the family, and were informed that she died some time ago; further enquiry elicited her death was due to typhoid fever. On looking at some of the well water in a tumbler glass it was perceived to be charged with sewage; no chemical analysis was necessary, the evidence was clear; there were disintegrated animal and vegetable remains, its colour was milky from soap suds, the taste and smell were conclusive. It would be no very bold statement to predict that this family cannot long imbibe this filth without incurring the same penalty suffered by the mother. Were anyone so far forgetful of himself as to administer a dose of strychnine to this family, and the fact became known (being a transgression of the law of this land) considerable agitation would doubtless be created throughout the country, every paper would chronicle the details, and the culprit in due course suffer for his misdeeds. Now the results to the family we conceive to be much about the same in either case, whether strychnine or sewage be taken; it is true that the first may act more sharply, although it is equally correct that the effects of the second are at times quite as rapid. At the moment of writing we have such a case before us. The effect upon the public mind is very different; if strychnine is administered, everyone anxiously enquires the particulars; if sewage be partaken of, not even the medical gentleman attending the family hints at such a thing, as if sewaged water were perfectly innocuous. Possibly the relative proportions of frequency may have something to do with this question, for undoubtedly where there is one case of poisoning by strychnine there are thousands from sewage; hence the first being rare creates a sensation, whilst the second is treated with indifference. A village with good water and perfect sanitary arrangements is a *rara avis*, such a one we have yet to discover. Ask at any village in England if they have good water, and you will be invariably answered " there is none better to be found, sir." Hint at any doubts you may have, when you are met with a smile of incredulity. Let a hamlet lose a score or two of its people from Typhoid or Enteric, and see with what stoical indifference the remainder continue to drink of the water that propagated the disease. We entered a house a little while ago wherein a case of Typhus was reported; it was in one of the villages previously referred to. A cursory observation showed no sanitary defects but the water presented to the eye, to the smell and taste only too sure evidence of its sewagey character. That the husband had imbibed his fever from the water we could not doubt, and we wondered to how many of his neighbours and others the disease would be conveyed, and the distance and time that would be involved in the process. We saw in our mind's eye that the excretal emanations from the afflicted person thrown to the rear of the cottage, gradually descending into the ground, assisted downwards by the daily slops and occasional rains until was reached the water bearing strata beneath but a few yards, from which the village wells are supplied. And this is another of the places from which Leicester derives a portion of its water supply.

The public water supply of Leicester being found of late years inadequate to the requirements of the people, another reservoir has just been constructed near to Bradgate Park, about six miles from the town. Strange as it may appear, nevertheless the fact remains, that no present provision is made for a pure and wholesome water; there is analogous origin, quality, and impurity in the drainage of villages, as in the older reservoir. Notably in the case of Newtown Linford, a considerable village, from which the sewage descends into the brook running through it, and this brook supplies the Bradgate Reservoir. In time of rain the whole stream is tinged of a light brown color, from the rich dark fluid of the farmyards and the sewage mingling with its waters. Also the water from the ditch of the churchyard empties into the brook beneath it. The graveyard is partly surrounded by the brook, whose waters impinging on the east wall, thence flowing along by the side and towards the opposite end of the churchyard enclosure. It hence becomes a question of great importance, and one that ought unquestionably to be solved, whether the drainings from the graveyard do not percolate into the stream which is at a lower level and in such very close proximity. For ourselves, judging by natural laws, and reasoning by analogy, we have little doubt in the matter. Yet, to be strictly just, it is necessary to add that we have ot proved there is actual communication between the two.

The Royal Sanitary Commissioners, in their report recently issued, state in reference to water supply and disease :—" Were an extensive analysis of water for domestic use to take place, there is no doubt that many sources now but little suspected would prove to be poisonous or unwholesome, and the prevalence of disease in many districts would be fully accounted for ; for this and other purposes seems eminently desirable." We concur heartily in this suggestion, having known very many instances where disease has been clearly traced to the unsuspected use of impure water. The concurrence between rainfall, impure water supply, and various diseases in Leicester having already been adverted to, little remains for the present to be added upon this branch. The causes of yearly diarrhœal attacks we clearly trace to the impure water supplied whilst a plentiful crop of germs is furnished by the villages before referred to. In the spring, when the water is in best condition there is little disease of this kind affecting the population, as time advances so does the complaint increase, and also the water becomes more and more impure until August or September, when is reached the maximum impurity of water, the maximum dryness of the ground, and the maximum developement of the disease. The cause of variation in the quality of water is this : the sewage of villages is pretty constant, and so probably is that portion which enters the reservoir. By constant we intend the solid material of the sewage, and without reference to the particular conditions of liquidity. Hence the quantity of sewage conveyed by these brooks during equal periods is practically the same, and it follows that the higher the rainfall the greater the volume of water entering them ; also the more diluted becomes the sewage, and consequently the purer the water. Conversely, the less the rainfall the smaller the volume of water conveyed, the sewage matter becomes more concentrated, and therefore the greater impurity of the water. When the seventy or eighty acres of reservoirage is covered as in Spring, there is a large volume of water, and the sewage matters become greatly diluted ; but when the water area is reduced to half a dozen acres, and probably less, as occurs in autumn, with consequent enormous reduction in the volume of water, the sewage and foul matter entering by the brooks, by percolation from the village above, and the fœcal matter of some thirty swans or so kept upon the face of the water to purify it (?) becomes concentrated, causing a greater impurity of water. Frequent analyses have proved the correctness of this reasoning. To the dissolved excrement of the swans is due in a great measure the sea green tint of this water in summer and autumn. It is likewise to be observed that the foul matter of the water bears varying degrees of hurtfulness, irrespective of mere volume or weight; the more putrid the matter, the greater its danger when taken into the system with water, and a greater quantity of non-putrid organic matter, presents less risk than a relatively smaller quantity of putrid matter, for the latter acts specifically as a poison. Now an elevated temperature such as summer and autumn heat produces greater decomposition and putridity of organic matter than the cooler temperature of winter and spring, and thus in the autumn we get a more dangerous water.

It will be seen why it happens that heat plays an important part in summer diarrhœa, but its mode of action is very different from that alleged by the Medical Officer of Health of Leicester, as quoted in another portion of this paper. Therefore, the public partaking of these waters suffer according to these varying conditions, and more so in the autumn, for that is the period of greatest organic contamination as well as dangerous stage of such matter. Diarrhœa affects all who partake of this water in a raw state, and in sufficient quantity, by which we mean as it flows from the taps, and without heating or boiling. We believe, as a rule, that infants and children partake of more liquid food than adults in proportion to their weight, and also of more water, for their elders have other draughts with which to quench their thirst. The diarrhœa is general with all ages and classes throughout the town, but the great bulk of deaths occur with the infantile population, from partaking of a greater amount of impurity, and being physically weaker than adults; from these two causes frequently succumb. When the autumn rains bring floods, and the reservoir again fills, thus diluting the previously concentrated impure water, the epidemic rapidly diminishes. At this period there is a large augmentation of fever cases, and we have no doubt it is due to the accumulation of putrid or semi-putrid organic matter from the sewage deposited in the common sewers during the prior dry summer season, becoming stirred up by the flood waters; and the sewage gas with the volatile putrid matter thus set free, displaced by the inrushing waters, the one flowing downwards and the gas upwards, entering dwellings and homes wherever there exists defective house drains and improper and imperfect ventilation, poisoning the inmates. A similar action occurs when the spring rains fall, especially with an interval of dry weather. The recent epidemic of scarlatina we attribute to the joint action of impure water and escaping sewage gas; and although it may be that the disease appeared in Leicester before the neighbouring villages whose sites are on the course of the brooks before mentioned, but of which, however, we have no proof —it had occurred in them long before becoming serious in the town. And so, by the agency of water, the active principle of the complaint and the germs had every opportunity of getting disseminated throughout the population, and in every direction. Likewise would the sewer gases spread the disease and its germs to all parts of the town, from the emanations of infected persons passing into the sewers. The inhabitants being rendered more susceptible to the complaint from consuming the impurities contained in the water, and we have fairly conclusive proof that such was so in a few cases enquired into. The autumn rains also assist in creating an intensified epidemic, by setting free and displacing large volumes of sewage gas.

Advertence having just been made to the sewer gases being likewise concerned in disseminating and intensifying zymotic disease, it is perhaps necessary to refer to the mode of action. In the first place it is as well to point out the system of drainage adopted in Leicester, so that our remarks may be rendered as clear as practicable to those who may be unaquainted with this somewhat intricate subject. It is now about eighteen years since the deep sewers were constructed on a very constricted scale, and at depths below the street surface of from six or eight to twelve or fifteen feet, varying with the localities and contour of the ground. These sewers, with their tributary branches and drains, commencing at all parts of the town and suburbs gradually converge to one point, joining at a distance of a mile or so from the central parts of the town on a piece of ground known as the meadow, and adjacent to the sluggish river Soar. The sewage having gravitated from every district now passes in a body through a main trunk sewer under the river, and into what are well known as the Leicester Sewage Works, where some years ago were manufactured the celebrated *Leicester Bricks*—more of this presently. The drainage of the town prior to the new works being carried out consisted of flat shallow drains, which emptied their contents generally into the river, canal, or other water courses, and likewise of a considerable number of privy cesspits, many of which latter yet remain to the indelible disgrace of the authorities ; and when these are emptied during the night or early morning into huge lumbering open wagons, the effluvia spreads with telling force in every direction, rendering the air not only loathsome and disgusting, but positively dangerous to be breathed. The risk is not confined to the locality of each cesspit emptied, but is incurred wherever the wagon goes on its journey through the town, and the smells are very perceptible long after its passage from the leakage that falls in the streets. We have often thought that *Punch's* remedy for the prevention of railway collisions, by setting a *Director* upon each buffer of the engine, might advantageously be employed with a slight transposition—for instance, to set a stout *Alderman* and attenuated *Councillor* upon each shaft of the wagon during the process of filling with the contents of cesspits would, doubtless, prove speedily effectual in abating the nuisance. The ancient drains yet remain, and in some instances do duty as sewers, but generally they act as relieves to the deeper sewers, by receiving the storm waters from the streets in wet weather ; moreover, retaining the heavier street detritus, that is more conveniently removed from these shallow drains than from the deep ones into which they ultimately enter with the flood waters. These old drains are very ramified, and spread over the whole town in an extraordinary manner, and are productive of no little injury to the inhabitants under whose houses they frequently pass.

The whole of the sewerage system, both ancient and modern, being closely connected and ramifying in every direction (in the case of the former sometimes in localities where they are little suspected), it will be readily understood that the sewer gases flow to every part of the town with great facility ; and it must be known that the sewers of Leicester generate a vast quantity of gas, primarily due to the defective condition of many of them and their flat gradients, whereby the flow of sewage is retarded, and considerable quantities of the suspended organic matter gradually becomes attached to the sides and inverts of the sewers, slowly choking them. This matter decomposing, fills the subterranean passages with gas and volatile organic bases, and be it understood that this gas flows in a direction opposite to that in which the aqueous sewage is travelling, so when the sewage descends the gas ascends. By this law excretal and other sewage matter—at least the volatile portion of it, and it is nearly all volatile at some period—may be conveniently transmitted to any portion of a town, no matter how distant from the place of original conveyance to the sewer, nor whether at a considerable elevation or lying in a valley ; because the gas will ascend to the elevated positions, and the fluid descend into the hollows. This being understood, it follows that great necessity is implied for due ventilation of these sewers, so that the gaseous products of decomposition may be conveyed away to the external air as rapidly as possible ; and to render them yet more perfect there should even be provision for letting in fresh air at the lower positions. By due ventilation we must explain is intended proper ventilation of every part of the drainage system considered as a whole, and not ventilation of particular places, fixed upon indescriminately, simply because certain factory chimnies or other convenient modes of ventilation are at hand. A dozen such ventilators in any one district will be of no material benefit to an adjacent district or system; in a word, each single sewer or drain must have its own perfect ventilation. And unless this is actually the case no town sewerage can be considered satisfactory.

Proceeding a little further, in periods of heavy rains and floods, unusual quantities of gas are produced; in the first instance each given volume of water entering the sewers displaces an equal volume of gas, and, secondly, as the waters rush through the sewers with accelerated velocity, the accumulated foul deposits on the sides and inverts are agitated, which operation sets free a great volume of gas previously contained in the deposits. Hence, efficient ventilation during floods is of the first consequence; in reality, proper ventilation of sewers is of quite as much sanitary importance to a town as the sewers. High winds, and winds blowing from certain quarters, such as the north and east, are disturbing elements to the sewers in the absence of proper ventilation; indeed we have noted greater pressure within the sewers during these winds, and in dry weather, than in periods of floods. The reasons of this are not quite obvious, but it is just possible that the change in barometric pressure in the case of a high wind may be the cause; and in the example of an east or northerly wind it may be due to the aqueous saturated and warm air of the sewers rushing to meet the dry cold air blowing from the direction just indicated. We have noted the pressure to be greatest when the wind is a high one, and blows from the east or north; this would be accounted for by such air being both rarified, dry, and cold. It will be observed that when the sewers are imperfectly ventilated internal pressure is created, and the gas being very subtle and penetrating will pass through the merest crevice conceivable when the sinks and grate traps are perfect; and when these are, as usually happens, imperfect, or the drain pipes are broken, improperly laid, possibly disjointed, brickwork decayed, joints without mortar, mortar rotten, and the thousand and one mishaps that are found in house drains, there the gas often issues with astonishing velocity, frequently a small hole in a pipe or brick emits gas enough to extinguish a lighted match or candle in a moment. Therefore, ventilation in sewers is essential, because the gas *will* otherwise enter houses, notwithstanding the *usual* precautions taken to keep it out; and it is somewhat remarkable that these escapes happen in many houses—

evidently a great many—without apparently the inmates being at all aware of the fact, indeed we almost daily observe it. Presumably this can only arise from innocence of the pernicious effects following the breathing of this foul gas, especially at night, coupled with the fact of constant exposure blunting the usual organs of perception.

Now in the absence of ventilation, zymotic disease and epidemics are spread through a town, because the complaint once introduced, the natural evacuations of the afflicted pass into the sewers, conveying great numbers of germs, and as the mode in which the aqueous and gaseous sewage is distributed has been already discussed, it will be at once perceived that the seeds and germs of epidemics are disseminated in a similar manner. Having reasoned thus far, it is necessary to inquire into the provisions made for effective ventilation of the Leicester sewers. In the aggregate there are a great number of ventilators promiscuously scattered over the town; most efficient many of them undoubtedly are. We can indeed conceive nothing better for the intended purpose than the tall chimney of a manufactory; these perform excellent duty in the particular sewers to which they are attached, and those manufacturers and others granting the use of their stacks for ventilation are conferring a much greater benefit upon the locality than so simple an action would appear to convey. On the other hand there are whole districts without any ventilation whatever, other than that finding a vent into the houses of the people, and similar extraneous and improper modes. It would be invidious to mention localities, still it is notorious there are districts in Leicester wherein the recent epidemic of scarlatina was most persistent, and families were swept off. The causes we have already treated upon, and need not repeat; it will suffice when we say that these afflictions were due to impure water, and impure air from the plentiful escape of deleterious sewage gas into the houses, and of this we have no earthly doubt. But whose is the blame? For to attribute these deaths to the act of God we conceive to be about as wicked and improper as to attribute to him the doings of the drunkard or thief.

The sewage, averaging in bulk from four to five million gallons per diem, having arrived at the works by gravity, is in ordinary times pumped into large tanks, and on its passage treated with caustic lime, for the purpose as originally intended of precipitating the stercoraceous properties of the sewage, and for purification; but in both these objects the process entirely fails. The manurial matters are only precipitated to a small extent, and the purification is practically *nil*. The reaction that takes place is this: when the caustic lime is mixed with sewage, the latter holding in solution considerable quantities of calcic and magnesic bi-carbonates, one equivalent of the carbonic anhydride is disengaged from the bi-carbonates, combining with the caustic lime, two equivalents of hydrated neutral carbonates resulting, and an excess of caustic lime always remains in solution. These carbonates are very flaky, and of somewhat gelatinous consistency, that gradually fall to the bottom of the tanks, carrying down with them some portion of the suspended particles of the sewage. The soluble portion of the sewage is scarcely any, if indeed at all interfered with; and when our readers are aware that the soluble substances are present in six or eight times greater quantity than the suspended portion (that which is visible), it is clear that the purification of the sewage is very incomplete—in fact scarcely commenced. Even the small part precipitated by the lime does not long remain there, for decomposition of the organic matter sets in, rapidly accelerated by the caustic alkaline state of the substance and surrounding fluid, so that the ascending gases (being products of decomposition) counteract the effects of gravity. In fine the whole is kept in an agitated state, and so the sewage ultimately passes from the tanks into the river in very much the same state in which it entered; true it is rather more decomposed, which cannot be a recommendation.

Now the wholesale daily discharge of such large volumes of sewage into a slow and sluggish stream necessarily results in ruining the river, of which any one whose olfactory organs are sufficiently fortified may be easily convinced by walking for a mile or two along its course, particularly a month or two hence. The effect of this wholesale poisoning is very serious upon the health of those who unfortunately dwell near to the river, and in the numerous villages and hamlets adjacent. No doubt this relic of barbarism has nearly ran its final course, and we need not dwell. No suggestions for improvement in this matter are necessary, for the town has recently been ably advised. We can only add that the Leicester process for treating sewage is the worst in every respect, whether of cost or results, of a considerable number investigated by us. Having pointed out in the course of these pages the evils from which Leicester derives her zymotic epidemics, and indeed sporadic attacks as well, the remedial measures must be self evident. These remedies, which must be sharp ones, lie with the inhabitants of Leicester themselves, who are yearly affected by these yearly outbreaks, for there is probability of another occurring ere long of a kind different from any that have recently afflicted them. We refer to small-pox; for after its appearance in any of the villages performing the functions of nurseries of disease to Leicester, no lengthy immunity can be reasonably expected. We are informed the disease has appeared at Markfield. As concerns the impure water the impurity must be ejected, no pollution allowed access into the streams, feeders, and reservoirs, from the numerous points of present collection. In the case of Thornton village, as it rests upon the ridge of a hill, its sewage must be diverted upon the opposite slope, instead of running down towards the reservoir. At the base of the sloping ground, near the edge of the reservoir, a deep channel may be cut to intercept all village drainage and the graveyard percolations, a few yards off. But unless carried well below the water level it will be quite useless. The other villages ought to be similarly treated, and wherever the contour of the country will not admit of better means, gravity must be overcome by suitable appliances. When this is done, and the *swans* removed, there will still remain quite sufficient impurity in the water from the drainage of six thousand acres of cultivated country comprising the gathering grounds.

The sewers of Leicester require thorough and efficient ventilation in every direction, not a single drain must be left without it ; every care being adopted of making the ventilating media thoroughly air tight, with proper exits at the top. These should be of sufficient elevation, and away from windows and chimnies, for the latter in warm weather, in the absence of fires, cause down draughts. There is no necessity for pursuing the subject further. The remedies are so extremely simple, we can only wonder they have been so long neglected.

One word more. Pending the introduction of a perfect ventilating system, the sanitary authority—the courteous reader will be pleased to excuse the incongruous phrase—will be wise in their generation if they were to put less water into the gulley traps of the broad and main thoroughfares of the town, and more of it, and more frequently, into those of narrow and confined localities; for to a close observer the present practice savours somewhat of the whited sepulchre.

So let Leicester beware! We wish the people a God speed in the improvements that are so much needed, and that can be executed at such comparatively little cost, for where the causes of zymotic disease are known, and are pointed out, the remedies become simple and unerring, and that the true causes of Leicester's yearly epidemics are those pointed out in this little pamphlet there can be no reasonable doubt—we have none. We clearly admit the existence of others that bear a certain portion of blame, such as dwellings erected upon made ground; this ground containing more or less garbage thrown in with the soil and *debris* to fill up the hollows. It is true there is not much of this in Leicester as compared with some other towns, but probably sufficient to account for occasional sporadic fever cases in these particular localities, more especially when wells are sunk through the made ground, and the garbage gradually becomes dissolved and carried down into the wells. We have recently examined the waters of a number of wells in a certain district of Leicester, belonging to houses erected upon made ground, at whose base there lies a substratum of very porous gravel and sand. These waters when submitted to analysis were found identical in composition, and contained a like amount and the same description of impurity, notwithstanding some of the wells are a considerable distance apart. The water of these wells is not good, and is below an average quality, yet the people appear to imbibe it without visible detriment. Nevertheless, a considerable risk is incurred, for it is exceedingly probable that the inhabitants will suffer eventually, should there be from any cause a concentration of organic impurity, which may easily arise from the stoppage of a local drain or sewer, when the sewage matter percolates the unmortared joints of the sewer crown. With a porous subsoil, like coarse gravel and sand, sewage contamination may be conveyed considerable distances, because the act of drawing water from wells disturbs the subsoil water level, thus setting in motion currents in various directions.

The depravity and neglect of families in certain portions of the population likewise tends to aggravate diseases; but upon due consideration and careful investigation, we are not disposed to attach much weight to this, for these classes are by no means the heaviest sufferers from epidemics.

One additional cause must be mentioned that is not confined to any particular class or division of the people, and therefore more general in its action; it is one to which little importance is usually given, we think erroneously. It is the adulteration of food, both liquid and solid, particularly the former, which practice is somewhat extensive. Of course epidemics are not caused by sophisticated food; but the more delicate children and weaker adults are thereby rendered more susceptible to their influence. and likewise the tone of the general health of the population correspondingly lowered. Indeed, that isolated cases of zymotic attacks do occur through the agency of adulteration there can be no doubt; we have noted several such instances. But after all, this turns upon the primary question discussed in this paper; what has been described is but adulteration upon a grand scale. Impure Water, impure Air, and impure Food are very synonymous terms, and often, too often indeed, arise out of each other. The whole may be well included in one word, and that is "Adulteration."

THE

SCIENCE OF DISINFECTION.

BY

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THE

SCIENCE OF DISINFECTION.

IN the midst of the confusing diversity of opinion among scientific men on disinfection and the agents capable of attaining it; in the midst of so much talk and conjecture made by both medical and non-medical men in the public journals; in the midst of the deplorable confusion between disinfectants, antiseptics, and antizymotics; in the midst of the singular facility with which it is given and received that a disinfectant *par excellence* is a certain mixture which does away with, or masks, the odour of putrefaction or other bad quality;—there is truly much need of receiving something less uncertain on this question, something which will be the result of severe comparative experiments, and not conceptions found or adduced from the property of impeding the putrefaction of organic substances, or of arresting or neutralising it, or neutralising or masking the smell.

These words are quoted from a review in an Italian journal, *La Nuova Liguria Medica*, of a short paper of mine, which appeared in the *Lancet* about twelve months ago, on Carbolic Acid and Zymotic Disease; and I am sure that anyone viewing the question disinterestedly and from a scientific aspect will readily endorse the writer's sentiments.

With the object, therefore, of offering something less uncertain on this subject, I shall presume to lay before you some results of, and deductions from, experiments lasting some years and entailing much close attention and trouble. Many of you must have observed that the words putrefaction and fermentation are frequently used as synonyms, implying thereby a belief in the identity of the putrefactive and fermentive processes, though they are sometimes employed as distinct terms without their difference being defined. Now, I think it can be shown, that whatever be the ultimate changes produced in a putrefying or in a fermenting fluid—and these are apparently the same—putrefaction and fermentation are not identical, and that this point constitutes the foundation of scientific disinfection.

If an aqueous solution of fresh beef juice be set aside for some hours and then examined microscopically, it will be found swarming with bacteria, vibriones, amocbæ, &c., in active motion. The fluid, hitherto clear and odourless, soon gets opaque and fetid. In this instance its reaction is of course neutral, but the result is the same were it moderately alkaline or very faintly acid. Furthermore, if the solution is put in a cool and dark place with exposure to air, it will be found at the end of from nine to twelve months still swarming with life, still cloudy and fetid, still giving an appreciable precipitate with nitric acid and heat, though these conditions are now less marked than at first. In a few months later putrefactive reduction is complete; the solution is still cloudy, but now free from putrid odour; a quantity of sediment lies at the bottom of the vessel; a stray microzyme is only seen here and there; it now gives a mere trace of precipitate with nitric acid and heat; and its specific gravity, at first perhaps about 1·6, and which has been gradually lessening, is now probably 1·1, or at most 1·2. Such are the physical characteristics of simple putrefaction; but there being so many kinds of organic matter, one or more of these appearances may accordingly be subdued, absent, or altered. For example, fresh healthy human urine, or hay infusion, soon teems with microzymes; both get clouded, but neither responds to the tests for albumen. The urine emits a moderate fetor, and, at first acid, gets alkaline; but hay infusion keeps comparatively sweet, and, at first neutral, remains so. Then, as is well known, putrefying organic matters yield very various offensive effluvia, according to their constitution and the surrounding medium. There is one condition, however, which is constant in all spontaneously decomposing organic substances, viz. the presence of microzymes. These organisms are certainly the first, last, surest, and in weak solutions frequently the only sign of true putrefaction, the faintest degree of which is coincident with their visible existence—developing or generating them, enduing dead matter with life, or kindling the tiny dynamics of vitality dormant in their as yet hypothetical germs. Some consider them the cause, others the result, of putrefaction; while some hold their function in nature as malignant, others as benign.

So much for putrefaction; and now as regards fermentation and disinfection. If to a portion of the same beef juice solution a quantity of a mineral, or any of the more common vegetable acids, be added so as to cause 'marked acidity,' the mixture will be found in a day or so to contain one or more small tufts of mycelia, their numerous filaments, partly dissepimented from fructification, radiating from a single nucleus, like those of thistle-down; also free spores and torlulæ. If the proper quantity of acid have been added, no microzymes are present, and the fluid, at first slightly hazy, soon gets clear; it has of course an acid reaction, a not unpleasant mouldy aroma, and in about four months, as compared with the putrefying fluid previously noticed, ceases to give a precipitate with nitric acid and heat. Supposing, however, that the solution is only rendered moderately acid, then it will ferment at first as before, but in a short time (commonly a few days) it also putrefies, and the two processes continue for a brief period. Latterly fermentation ceases, putrefaction continues, and the fluid is now neutral. Again, if to a portion of putrid beef juice a small amount of acid be added, then in a few minutes the contained microzymes die, and in a day or two minute fungus tufts are seen in the fluid, which now gradually ceases to putrefy, and continues to ferment till the process is exhausted. Again, if to a portion of putrid beef juice a slight excess of acid be added, the mixture is soon odourless, or smells like hawthorn blossom, or spiræa ulmaria, is nearly translucent, free from microzymes and fungi, but gives a precipitate with nitric acid and heat, and remains so indefinitely.

Furthermore, if to a portion of fresh or fermenting beef juice a larger quantity of acid be added than would cause and sustain fermentation *per se*, the mixture neither putrefies nor ferments; it keeps clear and odourless, responds to the tests for albumen, and continues thus indefinitely. (It may be here stated that the acid chiefly used in these experiments was hydrochloric.) The foregoing remarks do not, of course, apply to solutions of beef juice only, but to all fluids containing animal matter. (Specimens shown.) Now, these results are to me irrefragable proofs that putrefaction and fermentation, however correlated, or whatever ultimate changes they produce on animal fluids, are distinct processes. There are no two diseases of the human body with symptoms more opposite, definite, and diagnostic; there are no two pathological changes more different or pronounced; and whether their phenomena be considered from a chemical or physical aspect, they are found absolutely diverse. Such being the case, the question suggests itself, is organic matter as detrimental to health when fermenting as when putrefying? There is, unfortunately, in every town and village in the land abundant evidence showing that putrefying matter is very injurious to health, while we have no opportunity of ascertaining the effects of fermenting matter in this respect. Because putrefaction is natural and spontaneous, but fermentation, as explained, is artificial and involuntary. Judging, however, from the manifestations of the two processes, it is obvious that fermescence must be harmless as compared with putrescence, and their æsthetics as different as their influence on health. Putrid matter evolving noxious effluvia for nearly twelve months, cannot but be more hurtful than fermenting matter, almost odourless, and being fully decomposed in about four months. Nor are minute fungi any more than bacteria, proved to be hurtful when inhaled or swallowed; and those present in fermenting organic solutions are the same as those that grow in cheese, milk, fruits, or other acid animal or vegetable substances in a state of decay, and which are swallowed with impunity. Furthermore, there are many who hold, and I think rightly, that the specific toxic principles of at least typhoid fever and diphtheria are generated *de novo* from putrefying animal matter, which all zymotologists freely admit forms a suitable soil for propagating the whole genus zymotica. Now the disinfecting action of the stronger acids is undoubtedly in many cases owing to their property of substituting fermescence for putrescence, this being the sure result of their moderate use in disinfection. But, as already stated, these acids when added in excess prevent and arrest fermentation and putrefaction. Their action I hold to be thus destructive, in the sense that it dissolves and annuls by causticity the structural configuration of the organic texture or molecules, which being further immersed in an acid medium is thus rendered incapable of spontaneous decomposition. The indication of albumen in the fluid by the subsequent addition of nitric acid is less pronounced than when the mixture is newly made, suggesting the probability that it would ultimately cease to coagulate on the destructive influence being prolonged.[1]

This corroding action of acids on organic substances is, in a hygienic sense, obviously better than the fermentive action; and fermentation, in the same view, is again better than antiseption. If organic matter be fermented, it is probably rendered incapable of engendering or nurturing zymotic poisons; if cauterised, it is amorphosed, in the sense already alluded to; but if antisepted, it is preserved. Now the antisepting of effete nitrogenous substances, excremental or otherwise, has of late been the chief point aimed at in disinfection, and I concede that, as regards fresh animal matter about to putrefy and

[1] I have now found such is the case.

taint the air, it is beneficial. But what is the consequence if it be practised where a zymotic poison is present, say on an enteric or choleraic stool, or in an atmosphere contaminated with the infinitesimal toxic entities of diphtheria, variola, or typhus? Why, of course, that the poison is preserved as well as the offending matter. The multiplication of zymotic units may be arrested, but the virulence of those already generated or matured, is conserved. What prevents the molecular disintegration of the one, hinders also that of the other. Thus antiseption is seen to be an admirable contrivance for maintaining a constant supply of zymotic germs, or pathoplasts for future epidemics.

This fallacy seems to rest on the assumptions that contagia or infecta may arise *de novo* from, and are propagated by, decaying animal matter, and that because antiseption arrests decay it also renders these harmless. Hence carbolic acid has been largely used in smearing the bodies of small-pox patients; it has been kept vapourising in hospital wards, sick rooms, and other infected places; during the rinderpest cloths saturated with its solutions were hung over the horns of cattle, and their stalls and sheds coated with it; it has been given internally both to man and the lower animals for zymotic disease; it has been put into the bed-pan about to receive typhoid and other excreta; the bed clothes from fever patients have been held as harmless when soaked in its solutions; in short, it has been implicitly relied on as a prophylactic of, and antidote for, every phase and kind of contagia and infecta.

Now there are no valid grounds either on logic or fact to assume, as is constantly but I think unconsciously done, that because carbolic acid can prevent or arrest putrefaction, it can also annihilate or annul zymotic poison. To quench decomposition is one thing, and to kill infection another. Sequelæ are not necessarily affected like their cause. As common salt differs in its properties from sodium and chlorine, and hydrocyanic acid from hydrogen, carbon, and nitrogen, so zymotic poisons differ from merely putrid matter. What affects sodium or chlorine separately, does not necessarily affect in the same way common salt; and what affects isolated hydrogen, carbon, or nitrogen, does not therefore similarly affect hydrocyanic acid. Hence, what affects decomposing organic matter does not, as a consequence, in like manner affect zymotic poison. I now proceed to show that contagia and infecta are probably preserved rather than destroyed by carbolic acid, and also to point out some additional facts which indicate a scientific and reliable method of rendering these inert.

1st. A saucerful of pure carbolic acid liquefied by a minimum of water was enclosed within a glass bell-jar of one cubic foot capacity. Twelve hours after, when the jar was filled with strong carbolic emanations, a slip of glass with a minim of vaccine lymph on its surface was placed in the centre of the jar, where it was kept for 36 hours along with the saucerful of acid. The lymph was now moistened with water and glycerine and the reaction found to be neutral; it was then sealed in capillary tubes, and in a few days a child successfully vaccinated with it. Several tubes were filled from the resulting vesicles.

2nd. The lymph from one of these tubes was mixed with ♏i. of a 1 in 50 aqueous solution of carbolic acid ($\frac{1}{50}$ gr.), allowed to dry, exposed to common air for 10 days, moistened with water, reaction neutral, and a child successfully vaccinated with it. Vaccinations with the lymph from the resulting vesicle all succeeded.

3rd. A tube of vaccine lymph was mixed with ♏ii. of a 1 in 20 aqueous solution of carbolic acid, equal to $\frac{1}{5}$ gr. of pure acid. The mixture was milky from coagulation of the lymph. It was at once sealed in tubes. Five days after a child was vaccinated with it. A week after the operation was seen to be unsuccessful—the scratches on the child's arm being quite healed.

4th. A tube of vaccine lymph was mixed with ♏ii. of a 1 in 20 aqueous solution of çarbolic acid, equal to $\frac{1}{5}$ gr. pure acid. The mixture in this instance, instead of being sealed in tubes, was exposed on a slip of glass for 14 days, and a child successfully vaccinated with it.

5th. I repeated this experiment, excepting that the carbolized lymph was exposed only 12 days. Vaccination was again successful.

6th. Separate portions of vaccine lymph were exposed to various volatile media in the same manner as in the 1st experiment, but only for 24 hours. They were then liquefied with glycerine, the reaction of the mixture ascertained, and sealed in tubes till children were vaccinated with them. The results showed that with the mixtures of lymph and glycerine which were neutral or alkaline, vaccination was successful, while with those that were acid it was unsuccessful. These experiments were repeated with the acid bodies only; but the acidized lymph, instead of being sealed in tubes, was exposed to the air for about 12 days in order to see whether, as was the case with carbolic acid, the infecting power of the lymph was merely suspended. The results, however, were the same as when the lymph was sealed in tubes. The following is a tabular form of these :—

Results of vaccinations with Lymph exposed to the vapours of the undermentioned bodies.

Successful	Re-action of Lymph and Glycerine	Unsuccessful	Re-action of Lymph and Glycerine
Carbolic Acid	Neutral	Chloride of Lime	Acid
Chloroform	Alkaline	Sulphurous Acid	,,
Camphor	,,	Nitrous ,,	,,
Sulphuric Ether	,,	Glacial acetic ,,	,,
Iodine	Neutral	Hydrochloric ,,	,,

Regarding the 1st of these experiments, I wish you particularly to bear in mind this simple but important truth, namely, that the infecting property of a minim of vaccinine is unimpaired after being buried for 36 hours in the heart of a cubic foot of concentrated carbolic vapour.

In the 2nd experiment, ♏i. of a 1 in 50 aqueous solution of carbolic acid mixed with a tube of lymph and exposed 10 days has no effect on the physiological property of the lymph. In the 3rd experiment a small tube of lymph mixed with ♏ii. of a 1 in 20 aqueous solution of carbolic acid, that is a saturated solution, the acid present being equal to $\frac{1}{5}$th of a grain, and the mixture sealed in tubes for 5 days, failed to vaccinate.

The 4th and 5th experiments are repetitions of the 3rd, excepting that the mixtures of lymph and acid were exposed to common air for 14 and 12 days respectively before being used to vaccinate, which was done successfully.

The results of the 4th and 5th experiments show that even when lymph is incorporated with what is manifestly a large quantity of acid (nearly equal parts), its infecting property is but suspended, and that too only when the mixture is hermetically sealed from the atmosphere, as in the 3rd experiment. Whereas, in the 4th and 5th experiments, where the mixtures were exposed and the acid allowed to vapourise, the lymph, as stated, was normally active.

Now, when vaccinine is thus so obviously unaltered by carbolic acid, and remembering that vaccinine is inimical to varioline, if we are to be allowed to reason at all, it seems a just conclusion that, at least to a similar degree, will varioline be unaltered by carbolic acid, and if so, I submit there is a strong presumption that all zymotic poisons will, under the same circumstances, remain active ; and not only so, but that carbolic acid rather antisepts—rather preserves than destroys their infecting powers. Moreover, it will be conceded that the conditions of the experiments were highly in favour of carbolic acid, the proportion of that substance present being greatly in excess of the quantity which it is possible to use in practical excremental or aerial disinfection.

According to a short paragraph in the *British Medical Journal* of Feb. 21, 1874, these experiments and views have been confirmed in a rather remarkable manner. It reads thus :—'It is stated in American medical journals that so signal was the failure of carbolic acid as a preventive of yellow fever in New Orleans and Mobile, that suspicion was awakened that its effect was positively injurious, and that it helped to spread the disease.'

Vaccinine, however, as I have shown, can be rendered inert by exposure to certain acid vapours for 24 hours (though I believe a much shorter time would suffice) and otherwise under the same conditions in which it is unaffected by mixture with carbolic acid vapour for 36 hours. All true science harmonises, hence this fact might be inferred from the influence of acids on organic matter already adverted to. In this instance I am disposed to consider their action destructive, as the moisture in lymph is insufficient to permit of fermentation. These vapours, as seen in the table, are sulphurous, nitrous, acetic, and hydrochloric; the chlorine from chloride of lime producing also hydrochloric and hypochlorous vapour. Now, when vaccinine can thus be made inert, I think there are strong reasons for concluding that so will variola, because as vaccinia prevents variola, so that which destroys the infecting power of vaccinia must, of necessity, destroy the infecting power of variola ; and moreover, I hold it would be justifiable, in practice, to extend these inferences so as to include all infecta and contagia. Unfortunately, in the present condition of our knowledge, such conclusions cannot be tested practically, we dare not experiment on an unvaccinated person with variolous matter destroyed by inference only ; and, as you are aware, the specific toxic principles of the other zymotica have not been isolated.

There are many more bodies, such as acid salts, which are probably antizymotic from their acid reaction; but as this quality is generally weakened by combination with a base, the acids *per se* should always be used. It so happens that hydrochloric acid, besides being as effective as any, is the cheapest of all acids. This substance, as you know, may be had in any quantity, at a price next to nothing. The commercial acid, diluted with about 50 parts of water, is a fair strength for general disinfecting or antizymotic purposes, though it may be used stronger. In all cases of zymotic disease under my care, I advise that the patient's clothes be steeped for 12 hours in such a solution; and in typhoid fever that a portion of the same fluid be put in the vessel which receives the excreta, and before this is disposed of, that it be mixed with more of a stronger acid solution, also that a portion be sent down the closet soil-pipe afterwards. Hydrochloric acid, unlike nitric, has almost no action on lead in the cold.

I will here digress shortly to notice a substance which is very generally recommended as a disinfectant, more especially of typhoid and choleraic excreta, namely, ferrous sulphate. Supposing you add to separate portions of healthy and enteric fæcal matter a little of an aqueous solution of this salt, you would in the first instance find no change in the aspect or odour of the mixture, while the typhoid excrement would have become a dirty black and free from putrid odour. Now I apprehend it is in consequence of such alterations that the use of ferrous sulphate is advocated in disinfection. What, then, is the rationale of these phenomena? It is this—sulphuretted hydrogen is the chief cause of the fetor of healthy and putrid excrement; at any rate I am sure that bodies which decompose sulphuretted hydrogen can be made to deodorise such matters. But putrid enteric, and stale excrement also contain ammonia, with ammoniaco-magnesian phosphate. Now hydrogen sulphide and ferrous sulphate are only mutually decomposed in alkaline solutions; hence as healthy fæces are acid, no decomposition or deodorisation takes place when ferrous sulphate is added, whereas both ensue with typhoid and decomposing healthy fæces, these being alkaline as already stated. (Experiment shown.) Sulphate of iron, therefore, is not a deodoriser in every case; the medium in which it is to act must be alkaline of itself, or made so. But, moreover, the mere removal of fœtid odour from putrid matter does not imply the destruction or disarming of infecting particles. I have found that ferrous sulphate retards putrefaction to a fair degree, and I think it does so chiefly by appropriating the atmospheric oxygen that would otherwise combine with the organic matter, also by being slightly acid, and not by any caustic action. For the latter reason I should not consider a typhoid stool rendered innocuous, however black or inodorous it had been made by ferrous sulphate, until it was well drenched with a strong acid. In short, sulphate of iron is practically merely a deodoriser, and that only in alkaline solutions.

The experiments with vaccine lymph also prove that to aerial disinfection acids are effectively, largely, and easily applicable; hydrochloric, acetic, sulphurous, and nitrous acids being volatile, plentiful, cheap, and vapourised with facility. In practice I usually advise several platefuls of chloride of lime to be placed in various parts of an infected house, and the ignition of greater or less quantities of sulphur, as the case requires or admits of. Also, that the patient's body be sponged daily with an acid lotion, and acid drinks freely allowed.

I shall now very briefly refer to the action of alkaline substances on animal matter. In the course of the protracted series of experiments already alluded to, and which were made to determine the relative antiseptic powers of above 60 substances, as evinced by their preventing the appearance of fungi and animalcules in organic fluids with which they were mixed, I frequently observed that several of these bodies seemed rather to accelerate than retard the beginning of putrefaction. It was also noted that their solutions were either alkaline or neutral, from the bodies themselves being either alkalies, or alkaline earths, or their salts. Further investigations confirmed these results, which are in accordance with the fact mentioned by Dr. Gregory in his 'Organic Chemistry,' Ed. 3, 1852, p. 32, that bodies with an alkaline reaction, to which I may add neutral salts of the alkalies and alkaline earths, when mixed in small proportion with organic matter, hasten its decomposition—a fact which should be remembered by those who recommend the mere dusting of lime on open drains.

Such, however, is not the result if excess of caustic potash be added to a recent solution of animal substance; for although there is an almost instantaneous evolution of putrid odour, yet in a comparatively brief period it disappears, while the fluid remains free from fungi, fœtor, or microzymes, and soon ceases to give a precipitate with nitric acid and heat. Again, if excess of potash be added to a putrid solution of beef juice its microzymes quickly die; its bad odour, after a lengthened period, is gone; while its turbidity is changed to transparency, and it now gives no response to albumen tests.

Regarding the action of alkalies on vaccinine, which substance is itself alkaline, I have only three experiments to submit.

1st. Two tubes of vaccine lymph were mixed with mss. liq. pot., B.P. Twenty-four hours after the mixture, now dried into a film, was moistened with water, and a child vaccinated with it. The operation was *un*successful.

2nd. Two tubes of lymph were mixed with mss. of a mixture consisting of 1 part of liq. pot. in 20 of water. One day after the residual film was moistened with water and a child vaccinated with it. The operation was entirely successful.

3rd. Two tubes of lymph were mixed with mss. of a 1 in 20 solution of liq. pot. and water. The mixture was laid aside for 10 days, to see whether more prolonged contact of the potash and lymph would annul the latter's infecting powers, in accordance with the fact that alkalies hasten the oxidation of organic matter. The remaining film was moistened with water, and a child vaccinated with it. The operation was *un*successful.

The 1st of these experiments shows that the infecting property of lymph may be quickly destroyed by mixture with an excess of potash.

The 2nd proves that a moderate quantity of potash mixed with lymph does not soon annul its infecting powers.

The 3rd shows that if the conditions of the second are prolonged for 10 days, the lymph is made non-infective. From these results it may be justly concluded that variolous and other zymotic poisons would in the same circumstances be affected similarly to the lymph; also, that the other alkalies would act on lymph similarly to the potash, and in like manner on the other zymotica.

The action of acids and alkalies on organic matter may be summed up thus:—Acids added in small proportion to a fresh solution cause it to ferment, and prevent it putrefying. Added in large proportion, they prevent both putrefaction and fermentation. Added in small proportion to a putrid solution, putrescence is arrested and fermescence induced. Added in large proportion to a fermenting or putrid solution, both processes are arrested indefinitely. Vaccinine is quickly made inert by acid vapours.

Alkalies added in small proportion to a fresh solution, hasten putrefaction and prevent fermentation; added in large proportion, they prevent both fermentation and putrefaction; added in small proportion to a fermenting solution, fermescence is arrested and putrescence induced. Potash added in small proportion to putrid solutions, exacerbates putrescence; added in excess, putrefaction is soon expended. Potash mixed in large proportion with vaccinine, quickly makes it inert; mixed in moderate proportion and for a short time, it remains active; mixed in moderate proportion for 10 days, it ceases to infect.

In conclusion, it may be stated that special reference to the various doctrines of the immediate causes and nature of putrefaction and of zymosis, and also regarding the *modus operandi* of many well-known disinfectants, has hitherto been purposely avoided. These, though very interesting, consist chiefly of hypothetical data, so abstruse and complex that their consideration would in all probability contribute to no practical result. Nevertheless, this paper would be somewhat incomplete were the apparent modes of operation of disinfectants not, at least, briefly noticed. These I endeavoured to classify, but no arrangement I have made or seen has satisfied me. The following is that of Dr. Letheby submitted to a meeting of medical officers of health held in London last October. He divides disinfectants into four classes, to use his own words, 'according to the manner in which they seem to destroy or prevent the hurtful thing which causes offence or produces disease.' As examples of the first class, he alluded to the effects of cold and dessication, which strengthen the affinities of organic substances, thus enabling them to resist decay. Second. To the coagulation of albuminous matters by alcohol, creosote, the mineral acids, and most mineral salts which thus produce new compounds, not susceptible of organisation or decay. Third. To the oxidizing effects of chlorine, hypochlorous acid, permanganate of potassium, and atmospheric air, aided by water and porous bodies, which hurry on the changes of decomposition and oxidation, so that the particles may quickly arrive at the final stages of decay, and be quickly brought to rest. Fourth. To sulphurous, carbolic, and cresylic acids, and to the volatile oils which are found to have specific powers of disinfection.

I shall not discuss this arrangement further than to remark that the majority of such bodies are capable of acting in more than one of these ways. Also, that the action of a disinfectant depends in some degree on the proportion in which it is mixed with organic matter. But, assuming the relative disinfecting powers of the bodies mentioned as ascertained, the prior statement still holds good. Numerous examples might be cited. I shall give one. Chromic acid is a powerful coagulator of albuminous matters; it has a strong affinity for water (which, I may remark, is considered the *modus operandi* of antiseption by common salt); it is also a strong oxidizer, and therefore deodorant.

I am aware the imperfections of this communication are numerous, for which I plead the great difficulty of the subject, which, however, I trust my remarks will tend to lessen. Two points are worthy of reiteration. 1st. Putrefaction of organic matter may be impeded, arrested, or neutralised, or the odour neutralised or masked, and yet any zymotic poison present, in all probability, be unaffected, conserved, or only made dormant for a short time; in other words, the experiments with carbolic acid and vaccinine show that the use of pure antiseptics as antizymotics is a palpable paradox, preservation being practised and destruction expected.

2nd. The mineral acids are true disinfectants, they prevent putrefaction, they arrest putrefaction, they transform putrefaction into fermentation, they deodorise, and, what is most important, they are highly antizymotic as regards vaccinine, and therefore *à priori* of other contagia and infecta.

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