A CONSIDERATION OF SOME OF THE FALLACIES WHICH ARE BASED UPON A NARROW VIEW OF THE GERM-THEORY.*

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SOME writers fall into serious error when they put forth theories regarding the causation of enteric fever, which are based upon possibilities and which are not in accordance with every-day experience. They are forgetful of the evanescent nature of the matter which spreads the disease, and also of the certainty that, if the requisite conditions are departed from, there will be no production of fever. They assume that, if an enteric germ or particle of potent matter find admission to an ordinarily pure water-supply, it retains its vitality independently of the circumstances in which it is placed, and thus they make it differ from all similar living matter.

There are two fallacies which are based upon this idea, and which are prevalent at the present time. They are put forward by advocates who are forgetful of the protection which nature provides against evils, especially those which they confidently assert to be in store for those districts in which their views are not immediately carried out.

The first fallacy is, that there is no limit to the distance to which the contagia of disease can be transmitted by underground streams, and that no amount of filtration will remove or alter the particles upon which the contagium depends for its specific power.

The second is, that neither microscopical nor chemical analysis is able to prove the absence of such particles, and that conclusions based upon those analyses are likely to lead to disastrous results.

The authors who use these ideas point to cases which they assume to be sufficient to support their statements. This has been especially so in regard to outbreaks of fever in districts which are supplied with water from deep wells. But, until there is proof that an epidemic of typhoid has been distinctly caused by a water-supply which has been shown to be microscopically and chemically pure, reasonable men ought to hesitate before they accept the doctrine as a contingency at all likely to arise.

The statements are used for the purpose of assailing the character of waters which microscopical research and chemical analysis of specimens taken at their source have uniformly shown to be pure. Nevertheless, zymotic disease has continued to appear in the district, arising occasionally at distinct intervals in batches of cases. Their origin has generally been explainable by importation, by milk distribution, or by defective sewerage arrangements, which have been quite sufficient to account for them. Yet some persons have put these aside, and have accused the water as the immediate and direct cause of all the zymotic diseases which have appeared in the district (as, for instance, in Croydon). It is argued also that water which has been once polluted by mischance or accident is utterly unfit to be used as a public water-supply, and it is assumed that there are no safe provisions in nature for restoring it to a state which will fit it for use as a potable water.

If these conclusions could be established, there is scarcely a large town in the kingdom which could not be called upon to execute gigantic schemes for water-supply, ostensibly to avoid infinitesimal causes of danger; whilst the suggested schemes (when any are suggested) would be just as open to the causes which produce mischief as those which they propose to supplant.

The suggestions which have given rise to the false premises upon which the conclusions are based are such as those which were made by Dr. Frankland when reporting upon the cases of typhoid fever which arose at Lausanne in 1875, and also by Dr. Thorne Thorne at the conference on national water-supply which was held at the Society of Arts in May last. Dr. Seaton also, at the same time and place, put forward the idea that analysis was not to be depended upon for the detection of the contagia of disease in potable water. But Dr. Thorne Thorne would be the last person to advise that the source whence the Caterham Company derive their supply should be changed; but others, trusting in Dr. Frankland's admission, that neither the microscope nor the test-tube could show a typhoid germ, have advised that similar waters always

having a satisfactory chemical report should be changed as sources of supply.

The grounds for this advice are, that there is evidence in the water of previous sewage contamination, as shown by the presence of nitrates and nitrites. These, they argue, must have been obtained from animal contamination. They say that the water has been derived from a collecting-ground which has been made impure on its surface by cultivation of the soil, by animal-feeding, and by defilement by human beings; that, as neither the microscope nor the test-tube can discern with certainty the germs which are capable of developing enteric disease, there are no means of knowing whether they are present or not until the disease arises; that, if such germs are distributed on the surface of the soil, there is no certain power in filtration which will alter their character; although they do not deny that filtration has some power. They argue that the germs of matter upon which the propagation of the disease depends actually increase and multiply in the soil itself, and not in the bodies of the patients. They also state that a rise of water in the subsoil, which rise is always caused by a heavy rainfall, will bring the germ from the soil into the water and enable it to spread the disease, without necessarily bringing into the water the other accompaniments of sewage-pollution. Thus, water pronounced pure by the chemist and the microscopist may yet (they say) be teeming with germs of matter capable of setting up enteric fever and all the class of zymotic diseases.

The well-known theory of Pettenkofer is taken up and dissected. He affirms that the conditions necessary for the production of typhoid are, an impure and porous subsoil saturated with water, and the level of the ground-water or water-line rapidly falling after attaining an unusual height; whilst another authority—Buhl—takes the converse, and believes it to be the rise of the water-line in the subsoil which spreads the malady. Neither of these authorities states that the water thus contaminated was absolutely pure. They infer that the soil is contaminated by organic matters and surcharged with carbonic dioxide. This is necessarily absorbed with other impurities in large quantities by the water. The engineers, who are so anxious to change the sources of supply to which I refer, catch hold of Pettenkofer's and Buhl's theory; separate the first part from the second, leaving out the latter, and attach the former to Dr. Frankland's admission, that the chemist is not necessarily able to detect the germs of living matter capable of developing into the cacozyms or micrococci which set up typhoid. They seize hold of the fact that the water may be perfectly transparent to the electric beam of light, and yet soon after be full of living germs. They conclude that similar conditions will be persistent, without reference to the circumstances under which they are placed. The hybrid theory which is thus produced is launched as if it had the support of the great names with which it is associated, and is used at public meetings of ignorant ratepayers with wonderful effect.

I will examine the evidence given in support of this theory by the light of my own observations and experience; and for this purpose I must refer to the epidemic of enteric fever which arose in 1875 in the town in which I reside. It has been published that neither imperfect sewers, intermittent water-supply, nor personal infection had anything to do with that epidemic, and it is said that the water alone, as obtained from its source, was the culprit. Dr. Buchanan made an exhaustive statement regarding that epidemic to the Local Government Board, which appears in the annual report published in 1876. He inquired into the particulars of 1,164 cases which occurred during its progress. Previously to Dr. Buchanan's inquiry, and whilst the disease was in progress, I published in the *Times* newspaper, and also in the *BRITISH MEDICAL JOURNAL* for November 20th, 1875, statements as to the cause of the disease, the means which ought to be taken to remove its incidence, and to prevent its recurrence. Nearly four years of further experience have now been gained, and there is no reason whatever to alter the opinions I then expressed—viz., that the water (although in a great measure the exciting cause of the disease) was pure at its source; that it became contaminated during its distribution; and that such contamination was caused by the local circumstances incidental to the arrangements of the local authority. Those arrangements were such, that the water was liable to serious pollution whenever the supply was made to be intermittent instead of constant; that, from a series of circumstances, a distribution of fever-poison occasionally took place in the district; that, after this general distribution by means of water had ceased, defective sewers and imperfect house-drains caused the inmates of individual houses to suffer more or less from the exhalations which arose from deposits containing typhoid excreta, such deposits being retained in the neighbourhood of the houses in question or in the sewers with which those houses were connected; that, undergoing chemical change *in situ*, the germs of disease-producing matter were set free and conveyed by the drains into the houses, and disease was produced in those who were liable to its incidence. These outbreaks occurred at irregular and

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uncertain intervals, according to the time when the deposit in the sewer happened to be disturbed.

The causes to which I attributed the propagation of the disease required for their removal an alteration of the fittings in a very large number of houses, and also a serious rearrangement of the sewers, involving a large general, but still more unfortunately a large individual, outlay. The proposed outlay was not a new suggestion; it had been urged upon the local authority for several years. A gigantic effort was made, by appeals to popular prejudice and to the ignorance of the masses, to prevent the suggested alterations, and a violent outcry was raised to prevent the completion of works which were urgently required to enable the local authority to provide a really constant water-supply instead of the fictitious one which had lately been in operation.

The two statements I have mentioned were most unscrupulously used; fortunately, without effecting the object aimed at. Had they prevailed, and had the popular clamour which was raised in the place been successful, the district in which I reside would still have had an intermittent water-supply; fever would have been often with us, and our proverbially healthy town would have continued under the stigma which bad work connected with both sewer-system and water-service had brought upon us. I mention the two together, because I am satisfied that it was a compound cause, produced by the two, which led to the troubles of 1875. In this view of the case I am fully fortified by recent experiences. The water-supply is taken from the same source as in 1875; it has been for the past two years entirely constant. The total mortality in the fever year of 1875 was 21.6 per 1,000 living. This is an indication of good general health. But the zymotic death-rate was high, reaching 3.66; it was nearly as high as that for the whole of London, and included ninety fatal cases of fever. In 1876, according to the returns of the medical officer of health, the death-rate fell to 19.7; in 1877, it was 18.08; and in 1878 it was 18.5. The zymotic rate in the latter year was 2.8, and included eighteen cases of enteric fever. Of these, seventeen occurred in the second half of the year; and Dr. Philpot remarks, in his report, that "the incidence of the disease according to a certain milk-supply was so marked, as to lead to the conclusion that the fever-poison was distributed with the milk". In this opinion I entirely concur. The milkman who distributed the milk to the people disappeared from the neighbourhood, and I could not find his whereabouts; otherwise I should have searched out the truth by means of a coroner's inquest upon one of the victims. But, as the man could not be found, and as he was the only witness who could have proved whence the poison was derived, there was no means of finding out its secret and of tracing to its source the real cause of the mischief.

It is a fact that, coincidentally with a constant water-supply, we have a complete absence of enteric fever, except as regards cases which are clearly traced to causes outside the range of water-service; and, although the milk was the vehicle by means of which the poison was conveyed into the houses, yet a predisposing cause existed there also, for the houses in which the fatal cases arose were just those in which defective sanitary arrangements also existed. Those who succumbed to the disease had been exposed to miasms from defective sewers. At the time, also, at which the epidemic arose, serious complaints were continually made to the local authority regarding smells from the sewers in the very district in which most of the fatal cases occurred.

The incidence of the mortality in 1875 was clearly within the watery district; and within that district it was in houses which had glaring sanitary defects in the construction of their drains, or which were in close proximity to such. I did not meet with a single case in which there had not been a departure from one or two canon laws of sanitary work; that is, in which either the sewers communicated directly with the interior of the house, or in which the water-services were not in some way directly connected with the sewer; this latter proviso seriously affecting every house on that particular main. These views are fully borne out by the evidence obtained by Dr. Buchanan. He states (page 46 of his Report): "Oftentimes in a group of houses resembling each other in their general sanitary arrangements, some particular drain-defect was discoverable in certain houses, but not in others; and it was as often found that the incidence of the fever was upon those which showed the drain-defect, but not upon houses which did not show it."

A typical case which came to my notice occurred in North Park. A drain common to two semi-detached houses was allowed, in defiance of the by-laws of the Board, to pass beneath the walls and under a living-room in one of the houses. A settlement had taken place, and the whole of the sewage of those two houses had been discharged into the subsoil beneath. Every person living in that house, with one exception, suffered from enteric fever; and several nurses who were employed to wait upon the sick contracted the disease; and, of the total number of eleven cases which were connected with that house, three were fatal. It was only after the patients were removed and the house evacuated,

that the continuing cause was discovered. The most noteworthy points in this case were, that the plans of the houses had been approved by the Local Board; the drains were said to have been examined by an officer appointed for the purpose before they were covered up; and a certificate had been given by the then surveyor to the Board that the house had been built in compliance with the by-laws of the Board; whilst, in fact, every one of the regulations of the Board as to direct communication with the sewer, as to ventilation of the soil-pipes and position of the drain, was directly contravened.

The origin of the disease in the first instance was, in point of time, coincident with the distribution of fever-germs in the water; but its continuance was manifestly due to the sodden state of the subsoil under the house. Cases continued to arise some time after the subsidence of the general epidemic.

On the first outbreak of the fever, the water was accused as the vehicle which had distributed the germ. I had even given warning that such an event would happen if the course which was being followed were continued. I was of opinion that pollution arose after the water had been raised from the bottom of the well. Analyses of specimens taken at its source were always good, whilst analyses of specimens drawn from a distance were unsatisfactory. Frequent complaints were made by individuals regarding the impurity of the supply as delivered. Specimens were produced (one of which I drew myself from the tap) which were contaminated to the eye, as well as to the taste and smell. For a long time, the Water Committee refused to allow that the cause was in the water; but eventually the evidence upon this point was so overwhelming, that they were obliged to take the measures which were necessary for immediate safety. The result of the epidemic of 1875 has been to convince the authorities of the necessity for perfect ventilation in the sewers; and of the advisability of a constant water-supply and a complete separation between the sewers and the water-services. A constant supply has now been given for between two and three years, and, as a consequence, there has been a comparative immunity from enteric fever. The other works are being gradually carried out; so that, if we should by accident be compelled to trust to an intermittent water-supply, the danger will be reduced to a minimum, and no general rise of fever need be anticipated. The inhabitants also are more fully alive to the necessity for sewer-ventilation, and no longer allow themselves to be led astray by absurd newspaper paragraphs, or try to cheat the local authority by putting up dummy pipes. The Board's officers now understand the reasons for ventilation, and do not so easily wink at a departure from the by-law upon this point. There is no proof whatever in the case of Croydon that a chemically pure water-supply was instrumental in producing enteric fever; but, on the contrary, there is abundant proof that the water was fouled after it left the well; that the fouling was detectable without the aid of chemistry; and that the incidence of the fever fell upon those who lived in houses, the air of which was contaminated with sewer-atmosphere.

The next case which is said to prove the truth of the statement that a chemically pure water was instrumental in producing a typhoid epidemic, is that afforded by the Caterham outbreak. The Caterham Company had found that the demand for water exceeded their power to supply. They were in a similar position to that of the Croydon Local Board in 1875. They began works to enable them to increase their power of supply; and they partially suspended Clark's process for softening the water, which they had habitually used. Complaints arose that the water was not only deficient in quantity, but that it was also hard and turbid. Some families, who could obtain other water, ceased to use it just at the time at which the distribution of typhoid excreta took place, and they escaped the consequences of the outbreak. Dr. Thorne Thorne traced the cause to the distribution of typhoid excreta. The advocates of the first half of Pettenkofer and Buhl's theory are not satisfied with the evidence, and have stated that Dr. Thorne Thorne's views are not proven; but no unprejudiced person can read his report without being convinced as to the cause. But I demur to the idea that the chemist would not have detected the pollution if he had had an opportunity. No analysis was made by a chemist at the time when actual distribution was effected; and there is no foundation, therefore, for the statement that analysis did not detect it. In fact, an analysis was made by Dr. Hilliard, a medical man residing at Caterham, and who, as a pupil of Mr. Wanklyn, was fully competent to make it. The specimen analysed was drawn on February 1st, at which time the company had taken alarm, and were pumping water to waste which had been previously sent into the general supply. Dr. Hilliard also tested the water from the reservoir as supplied to the people. Free ammonia was absent; but it contained .05 of combined ammonia in parts per million. He examined the water which was pumped to waste; it contained .04 of free ammonia and .05 of combined ammonia. Water drawn from a tap in the analyst's own house showed a perceptible amount of free ammo-

nia, viz., .013; whilst the combined ammonia amounted to .07. The quantity of ammonia which ordinarily belongs to the Caterham water is far below that which Dr. Hilliard found in water as supplied to the people on February 1st and 2nd of this year. I think this is conclusive of contamination from an outside source. If the analyses had been made ten days earlier, when the distribution was in operation, it would have been much more decided. There was no suspicion as to the nature of the pollution until after the distribution of the polluting matter. It is said that analyses have been made of water to which so much urine had been added, and yet the analyst had not been able to detect the addition. The user of this argument has to show that such water had given rise to typhoid or other enthetic disease. The urine thus added to pure water would have its organic matter immediately oxidised by the gases contained in the water, and it would be reduced to innocuous matter. This is no proof that analysis is unsatisfactory, because it fails to detect small quantities of organic matter in large quantities of water. There are powers in nature sufficient to protect the people from such accidents, and able to destroy evidence, and by that means destroy the disease-producing power, in the water. If the chemist cannot detect it, pollution has not advanced beyond the protecting power which is contained in the water itself.

The Caterham epidemic was mild in its character, and produced a low mortality, corresponding in this point with similar so-called accidental epidemics. I infer that this mildness was due to the healthiness of the district in which it arose, but many of the people are living in unsatisfactory conditions. The houses are supplied with cesspools sunk into the chalk, and some of them are so arranged that the products of decomposition, whenever they arise, must find admission into dwelling-houses; but, in consequence of the porous nature of the geological formation of the district, there is no general production of sewer-gas, and the cesspools do not easily fill. I was not able to obtain information regarding the house-arrangements in all the fatal cases; but, in some, there were defective conditions likely to damage the health of those residing within their influence. If the sanitary conditions of the houses had been in compliance with the canon laws of sanitary science, the distributed germs would have aborted, or would only have produced a slight febrile disorder. The character of the case will not always depend upon the size of the dose, although a frequent repetition will lead to aggravation, and eventually produce a bad case. A single germ planted in a favourable soil may at once produce a bad case; but the habitat of that case must have had unsanitary surroundings. A repetition of the dose, if given to a person inhabiting a healthy house, may in the end set up a typical case of fever; but, as a rule, it will be mild if the surroundings of the patient be satisfactory, his health good at the time at which the doses are administered, and the administration cease as soon as the fever is set up. There was no continued repetition at Caterham after the first few days. The cause being removed, new cases ceased to arise, except in a few instances in which it is probable that secondary causes were at work. It is also probable that the stage of incubation varies, just as occurs in the vegetable world; seeds planted in a given soil do not all spring up at the same moment of time.

Reasoning from analogy, I may fairly assume that there were defective sanitary arrangements in all the houses of those affected, which damaged the constitutions of the victims previously to the reception of the fever-poison; although, of course, there might be other circumstances fully capable of accounting for the fatal termination. I have followed out by personal examination a large number of fatal cases in different districts; and I have scarcely ever failed to find that the sanitary arrangements of the house in which the patient resided had manifest departures from correct sanitary law. This has been denied sometimes; but the denial has arisen from a want of knowledge as to what sanitary law really requires. I place them thus: There has been either a direct communication between the sewers and the interior of the house, often unsuspected by the occupant; or the sewers and the water-supply have been in direct communication, so that an interchange of material took place, or the water as supplied was contaminated by a neighbouring household.

Experience gained in my own neighbourhood proves very clearly that germs of infectious or zymotic disease are evanescent in their vitality, and are easily destroyed by a combination of motion, dilution, filtration, and the action of vegetable life. The excreta of nearly twelve hundred cases of typhoid fever, with all the excreta from other cases which occurred in this district, were distributed, in 1875, over the fields upon which the sewage of Croydon is utilised. In a large number of instances, these excreta were not disinfected. The number of hands employed upon the farm then averaged from forty to sixty per week. A large number of persons were also employed in removing produce from the farm. No instance has been brought to my knowledge of typhoid fever or of any other zymotic disease arising among the people on the farm,

although I studiously sought for them. There has been an all but complete immunity from these diseases among the several thousands who live within a mile of the borders of the farm.

I gather from this experience that there is a retrocedent action going on in excreta which are in motion, and that air, soil, and vegetable life so alter its nature, that any further development of the cacozyms or micrococci of enthetic disease becomes all but impossible. Analogy teaches us that this must be so, otherwise the presence of a few cases of infectious disease in a given neighbourhood would, by loading the air with infecting matter, bring all persons liable to the disease within the range of its influence. Ventilation is found to be an effectual remedy against aerial pollution, assisted, no doubt, by other agencies. The particles of albuminoid matter which are able to produce disease do not retain their dangerous power for any considerable period, except as regards one form, which is persistent, and is similar in endowment to the resting spore of the fungi. Universal experience shows that, in the greater portion of them, they are evanescent, and are rapidly altered, so that they are then no longer able to produce fruit.

It is reasonable to assume that Providence has not left us unprotected as regards underground streams; that powers exist below the surface of the soil as well as above it. One of the means which produce this is that movement of water which is always taking place in the soil. Mischief only arises when that movement is arrested or becomes very slow, and water is brought to a state of rest (mischief, I mean, from the reproduction of disease-germs). Then we find miasmatic influences arise, and evil is produced such as Pettenkofer found in the subsoil of Munich. Circulation of air is impeded, carbonic dioxide is in great excess, the water becomes surcharged with it; and then those vegetable growths, which luxuriate in such an atmosphere, are able to assert their individuality, and the water teems with germs capable of setting up zymotic disease whenever that water contains organic matter in its composition. But a carbonic acid atmosphere cannot arise in a chalk-water whilst it is in contact with chalk, unless it be thoroughly saturated with the bicarbonate of lime. Carbonic acid is carried down by rain, or it is produced in an organic subsoil by oxidation. The acid comes at once into contact with the chalk, and is fixed as a bicarbonate of lime, and dissolved in the water. So long, therefore, as the water is in motion, and so long as it only contains some eighteen to twenty-two degrees of hardness, there is no carbonic acid atmosphere for cacozyms to run riot in: and without a pabulum for them to feed upon, it is not possible for fungi or algae, or other living things, to increase and multiply in the water of a chalk-formation in the manner which is possible in the shallow wells and the subsoil of Munich. I believe that chalk-waters are fully protected from the chance of such evils as naturally belong to shallow wells; and, so long as they have good chemical and microscopical characters, we need be under no apprehension of evil from their use. It is requisite, therefore, for those who are responsible for the provision of a water-supply to a given district to have it analysed at regular intervals, and to watch the changes which take place in its character. So long as these changes are in narrow limits, there is nothing to fear. If, however, analysis at any time show that alteration is taking place, it is for the authority to search out the reason for it, and to take measures for its removal; or, if it cannot be removed, then to be prepared to obtain a supply of water from another source before the contamination becomes dangerous.

PUBLIC HEALTH.—During last week, being the first week of the present year, 4,051 deaths were registered in London and twenty-two other large towns of the United Kingdom. The mortality from all causes was at the average rate of 24 deaths annually in every 1,000 persons living. In London, 1,754 deaths were registered, being 76 below the average, and giving an annual death-rate of 25.0. The 1,754 deaths included 8 from small-pox, 48 from measles, 73 from scarlet fever, 11 from diphtheria, 120 from whooping-cough, 22 from different forms of fever, and 10 from diarrhoea; in all, 292 deaths, which were 29 above the average, and equal to an annual rate of 4.2 per 1,000. The deaths referred to diseases of the respiratory organs, which had been 652 and 672 in the two preceding weeks, declined to 455 last week, and were 40 below the corrected weekly average. Different forms of violence caused 67 deaths; 61 were the result of negligence or accident, including 21 from fractures and contusions, 12 from burns and scalds, 3 from drowning, 7 from poison, and 13 of infants under one year of age from suffocation. At Greenwich, the mean temperature of the air was 34.8°, and 2.9° below the average. The mean degree of humidity of the air was 94. The direction of the wind was variable, and the horizontal movement of the air averaged 5.0 miles per hour, which was 8.2 below the average. Rain fell on four days of the week, to the aggregate amount of 0.05 of an inch. The duration of registered bright sunshine in the week was equal to 7 per cent. of its possible duration.