mucus is poured out, no decomposition of the urea occurs, and no alkalescence from volatile alkali is produced, and the earthy phosphates are not precipitated. I have hitherto occupied your attention with substances which are excreted in healthy urine; in my next lecture I shall pass to those which are occasionally thrown out in disease. I shall take first the occurrence of albumen in the urine.

ORIGINAL COMMUNICATIONS.

ON THE MODE OF PROPAGATION OF CHOLERA.

By JOHN SNOW, M.D.

(Concluded from page 562.)

Although, as I have observed, the influence of vitiated water in aiding the spread of cholera is now generally admitted, it must be stated that it is not usually understood to act in the way I have explained; but the contaminated water is thought by many to predispose persons, so that an unknown cause of cholera may act upon them in some inexplicable way. The manner in which these outbreaks occur, when caused by the contamination of a local supply of water, shows, however, that it does not act by merely inducing a predisposition. The water in many of the instances had been contaminated for months or even years, when a case or two of cholera occurring amongst the people on the spot, whose evacuations entered the water through the drains or otherwise, in a day or two afterwards there was a simultaneous outbreak of the malady amongst a number of the persons using the water; whereas, if the water had merely caused a predisposition, and was not acting as the exciting cause, the cases of cholera, however numerous in the locality, might be expected to be distributed over the period that the disease prevailed in the town or district in which the locality was situated. In a review in the *Medical Gazette*, in 1849, the remark was made, that as the communication of cholera to the first case in Albion-terrace could not be traced, and was of course not attributable to the water, which did not yet contain the cholera evacuations, the same cause which would produce that case would produce others in the immediate vicinity. This must be admitted to be possible; and in the same way, if a fire had taken place from some unknown cause in No. 13, and the whole row had been burned down, it must also be admitted that a fire might possibly have originated from the same unknown cause in all the other houses about the same time, and that the burning of the one had no connexion with that of the others. No one, however, would believe this to have been the case.

Besides the local outbreaks already alluded to, it can be shown, that the cholera was often communicated through the water, on a more extensive scale, by means of the sewers which empty themselves into various rivers, from which the population of many towns derive their supply of water. In several towns of this country, among which are Birmingham, Leicester, Bath, and Cheltenham, there were only a few cases of cholera, either in 1832 or 1849, and those chiefly in persons who had arrived from other places in which the cholera was prevailing, or among the immediate attendants of these patients. Now, all these towns were supplied with water from sources quite uncontaminated with the contents of sewers. In some towns so circumstanced, there has been a good deal of cholera, but then it was confined to the poor, and to particular localities in the towns; but, on the other hand, in all those towns in which the malady extended generally, and was not confined to the poor and dirty, this connexion between the sewers and drinking-water existed. A great part of London was in this condition in both epidemics; Exeter was so in 1832, and Hull in 1849. The difference between the two epidemics in Exeter and Hull, in connexion with an altered supply of water, is very remarkable. In 1832, the people of Exeter were supplied with water by water-carriers, who obtained it from two mill-streams diverted from the river; and one of the chief sewers of the town emptied into a branch of the river which divided into the two mill-streams. Cholera commenced with a woman and child who had just arrived from Plymouth, where the former had been nursing another child that had died of the same disease. It soon became very prevalent and severe for the size of the town. There were 1135 cases, and 345 deaths. (a) Subsequently to 1832, Exeter has been supplied by waterworks, with water derived from the river Exe, at a point two miles above the town, and more than that distance above the influence of the tide. In 1849, there were only about 20 cases of cholera in Exeter, nearly half of which occurred in strangers coming into the town, and dying within two or three days after their arrival.

In 1832 Hull was scantily supplied with water, conveyed in pipes from some springs situated three miles from the town; in the epidemic of that year the cholera was confined almost exclusively to the poor, and the deaths amounted to 300. Between that time and 1849, Hull, besides an improved system of drainage, obtained a more abundant supply of water. The water-works, however, are situated on the river Hull, two miles and three quarters from its confluence with the Humber. About half the sewage of the town is delivered into the river Hull, and the tide flows up this river for many miles past the waterworks, carrying with it the filth from the sewers. In the late epidemic the deaths from cholera and diarrhœa in Hull amounted to nearly 3000, and occurred among all classes of the community.

In London the cholera was most prevalent during both epidemics in those districts supplied with water vitiated by the contents of sewers and cesspools, and indeed it generally bore an exact relation to the amount of vitiation. The map from the second Report on the Health of Towns, which is suspended in the room, shows the districts of the metropolis supplied by the different Water Companies; and the other map, from Mr. Grainger's Appendix to the Report of the Board of Health on Cholera, is coloured to show the relative prevalence of the late epidemic in different parts of London. A large district on the north of the Thames is supplied with the New River water, which is not contaminated by the sewers; another district on the same side of the river is supplied by the East London Water Works Company, with water obtained from the Lea, above the influence of the tide, and nearly, if not altogether, free from contamination. These districts are not much tinged with the blue of cholera in Mr. Grainger's map, except in particular spots in which there was generally a local supply of contaminated water, as, for instance, in the neighbourhood of Bridge-street, Blackfriars, where many of the inhabitants obtained water for drinking from St. Bride's pump, which was afterwards closed in consequence of its being ascertained that the well had a communication with a sewer which emptied into the Fleet ditch; and in the vicinity of Shoreditch and at Hackney, where Dr. Gavin found the contents of the privies overflowing or percolating into the wells in certain courts and allies. The north-west districts of the metropolis are supplied with water by the West Middlesex and Grand Junction Water Companies, who obtain the water from the Thames, near Hammersmith and Brentford, where the river is in a great measure free from sewage at particular times of the tide, and the water is also purified by subsidence in large reservoirs. The districts so supplied were not severely visited by cholera.

The district supplied by the Chelsea water-works, was not severely visited by cholera during the late epidemic, as appears by the cholera map, except in particular spots where contaminated water was used, as in the neighbourhood of Duke-street, Chelsea, where many of the people obtained water by dipping a pail into the Thames. Now, the Chelsea Company derive their supply of water from the Thames at Chelsea, where it is very foul; but having till lately to supply the Court and a great part of the nobility, they have large and expensive filters, and also very capacious settling reservoirs, in which the water is kept for a considerable time before its distribution. Dr. Hassall found the Chelsea Company's water to contain much less organic matter than that of the Companies supplying the districts on the south of the Thames; and he found it to be free from the hairs of the down of wheat, yellow ochreous substance, (believed to be partially-digested muscular fibre,) and other substances which had passed through the alimentary canal, and were found in the Vauxhall and Lambeth Companies' water. (b)

The districts of London, on the south side of the river, are

(a) See "History of the Cholera in Exeter in 1832," by Dr. Shapter, to whose kindness the writer is indebted for additional information.

(b) A Microscopic Examination of the Water supplied to the Inhabitants of London.

supplied with water obtained from the Thames near the Hungerford Suspension Bridge, and at Vauxhall, by the Lambeth, the Vauxhall, and the South London Companies. The water is very imperfectly filtered through coarse gravel, and has little or no opportunity to subside; and according to the evidence of Dr. Hassall, mentioned above, it contains a great deal of excrementitious matter. The cholera was very much more severe on the south side of the Thames than on the north, as appears by the map. There were other causes for this besides the water supplied by the Companies. The wells in this part of the town are very shallow, and are often vitiated by the contents of the cesspools, which percolate through the ground; and a yet more important cause of the great prevalence and fatality of cholera was the existence of certain tidal ditches in Bermondsey and Rotherhithe, the places in which the mortality was greater than in any other part of the Metropolis in the late epidemic. These ditches were the direct receptacles of the excrementitious matters of a large population, and furnished at the same time the only supply of water that could be obtained by a great number of the inhabitants. I was furnished by Mr. Grant with the result of a house to house visitation in Jacob's Island, which is surrounded by one of these ditches, and it shows that the mortality from cholera was much higher among the people who had no supply of water except from the ditches, than among those who had access to the pipe-water of the Company.

In the epidemic of 1832, the part of this Metropolis most severely visited by cholera was the Borough of Southwark, in which ninety-seven persons in each 10,000 of the population were carried off, being nearly three times the proportion of those that died in the rest of London. Now, the Borough at that time was supplied by the Southwark WaterWorks with Thames water obtained at London-bridge, and sent direct to the houses without the intervention of any reservoir.

The communication of cholera by means of the water is well illustrated by the instance of Moscow, which was severely visited by that disease in 1830, but much less severely in the second epidemic. Subsequently to 1830 the greater part of the town, which is situated to the north of the Moscow river, obtained a supply of excellent water conducted in pipes from springs at a distance; and the cholera in 1847 was chiefly confined to those parts of the town which lie to the south of the river, to which the new supply of water did not extend, and where the people had still only impure river water to drink. (a)

The Table [copied and suspended in the room] from the Weekly Report of the Registrar-General of January 12, 1850, shows the mortality from cholera in the different districts of London supplied by the various Water Companies; and if the purification of the Chelsea water, and certain local contaminations of the water before mentioned be taken into account, the mortality will be found to bear a very close relation to the absence or presence of connexion between the sewers and the water supplied. It also appears from the same table that the average mortality from all causes in a series of years bears a relation to the quality of the drinking water. There is great reason to believe that typhoid fever and some other epidemic diseases are communicated occasionally through the drinking water; and there are a great number of facts in the history of the Plague that have led me to believe that it is communicated in exactly the same way as cholera. There are also many circumstances which render it probable that the cause of one disease not epidemic and communicable from person to person, but endemic, viz., ague—often exists in the water of marshy districts, and is acquired by drinking the water; but there is not space to enter on these subjects at present. (b)

The large public institutions of London, in which the inmates are shut up from the rest of the community, showed the influence of the water, or the absence of that influence, in a remarkable manner during the late epidemic of cholera. Bethlem Hospital and the Queen's Prison are both supplied with water from deep wells on the premises, and, although situated on the south of the Thames, in a district in which the cholera was very fatal, there was not a death from that disease in Bethlem Hospital, with a population of more than 400, and only one death in the Queen's Prison, with a population of 300 and upwards. In Milbank Prison, on the contrary, the cholera was very prevalent until the greater number of the prisoners were sent away. It was considerably worse, in fact, than among the population outside in the same neighbourhood. There were 113 cases and 48 deaths; the deaths amounting to 4·3 per cent. of the average number of prisoners. The water used in the Milbank Prison was obtained from the Thames at the spot: it was filtered, indeed, through sand and charcoal, but not kept for a while in large reservoirs like that sent from the Chelsea Waterworks to the rest of Pimlico and Westminster. In Tothillfields Prison, supplied by the waterworks just mentioned, there were 13 deaths from cholera among 800 prisoners, but in all the other prisons on the north of the Thames which are supplied with water into which the sewage cannot enter, there was but one death from cholera; that death took place in Newgate.

The first cases of cholera which occurred in London in the autumn of 1848 are particularly interesting with reference to the influence of the water of the Thames. According to the valuable Report of Dr. Parkes on the subject, subsequently corrected by him in one or two particulars, in consequence of some information which I received from Mr. Russell, surgeon, of Horsleydown, the first case of cholera in London (when the disease was introduced into this country from Hamburg, the greatest commercial town on the continent of Europe, as it had been just seventeen years before) occurred on September 22nd, in a seaman named John Harnold, newly arrived by the Elbe steamer. It is, indeed, said that cases of cholera occurred in London prior to this; and Dr. Copland mentioned one in the *Medical Gazette* as having happened on July 11th, in a man who had been employed on board of a steam-vessel from St. Petersburgh, where the pestilence was then prevailing. But, looking on the case of John Harnold as the first, then the next case occurred in the same room, on September 30th—eight days afterwards—in the person of a workman, named Blenkinsopp. These cases occurred in New-lane, Gainsford-street, Horsleydown, close to the Thames. In the evening of the day on which the second case occurred in Horsleydown, a man was taken ill in Lower Fore-street, Lambeth, and died on the following morning. At the same time that this case occurred in Lambeth, the first of a series of cases occurred in White Hart-court, Duke-street, Chelsea, near the river. A day or two afterwards, there was a case at 3, Harp-court, Fleet-street. The next case occurred on October 2nd, on board the hulk Justitia, lying off Woolwich; and the next to this in Lower Fore-street, Lambeth, three doors from where a previous case had occurred. The first thirteen cases were all situated in the localities just mentioned; and on October 5th, there were two cases in Spitalfields.

Now, the people in Lower Fore-street, Lambeth, obtained their water by dipping a pail into the Thames, there being no other supply in the street. In White Hart-court, Chelsea, the inhabitants obtained water for all purposes in a similar way. A well was afterwards sunk in the court; but at the time these cases occurred the people had no other means of obtaining water, as I ascertained by inquiry on the spot. The inhabitants of Harp-court, Fleet-street, were in the habit, at that time of procuring water from St. Bride's pump, which was afterwards closed on the representation of Mr. Hutchinson, surgeon, of Farringdon-street, in consequence of its having been found that the well had a communication with the Fleet-ditch sewer, up which the tide flows from the Thames. I was informed by Dr. Dabbs, that the hulk Justitia was supplied with spring-water from the Woolwich Arsenal; but it is not improbable that water was occasionally taken from the Thames alongside, as was constantly the practice in some of the other hulks, and amongst the shipping generally.

It must no doubt seem very unlikely to many that the materies morbi of a disease should pass for a distance of two or three miles through the water; but the propagation of

(a) Report of Swedish Commissioners, quoted in the Second Report of the Metropolitan Sanitary Commission. 1848.

(b) Mr. Wm. Blower, surgeon of Bedford, speaking of Wootn, near Bedford, says, "A few wells have been dug lately, and good water has been obtained, and there is every probability, that if the water pits were filled up, and more wells dug, and the draining completed, that sporadic typhus and ague which have so long infested this village, and occasioned so much distress and expense, might be entirely eradicated. A respectable farmer informed me that, in the neighbourhood of Houghton, a few years ago, his was the only family that used well water, and almost the only one that escaped ague."—General Report of Poor-law Commissioners on the Sanitary Condition of Great Britain, 8vo. 1842. P. 66.

Mr. Grainger also quotes some instances, at page 94 of his recent Appendix to the Cholera Report, in which a number of persons contracted intermittent fever by drinking marsh water, while others, exposed to the same atmosphere, who did not drink the water, altogether escaped.

plants and the lower forms of animals by seeds and ova which can be transported to a distance would appear equally improbable, were it propounded for the first time. Analogy leads to the belief that, however minute the particles which propagate cholera, they must yet have a definite structure, (probably that of a microscopic cell), and must therefore not be capable of dilution, so as to be rendered inert.

In the autumn of 1849, Drs. Brittan and Swayne, of Bristol, considered that they had discovered the cause of cholera in a minute fungus; and Dr. Wm. Budd, of the same city, met with the supposed fungus in various specimens of water used as drink, in places where the cholera was very prevalent. It was, perhaps, too much to expect, that we should obtain a knowledge of cholera more exact than that which we possess of syphilis, small-pox, and other better known diseases; and the supposed fungi were resolved into other things. As many of these, however, were particles of bran and other matters which had passed through human intestines, the labours of these gentlemen confirm the fact of the water in various places being a medium of communication between the alimentary canals of cholera patients and those of other people.

In one of the Registration Reports, in the beginning of last year, Mr. Farr pointed out a remarkable connexion between the prevalence of the cholera of 1849 and the temperature of the Thames. The probable reason of this connexion is, that the cholera poison does not so well retain its properties unimpaired in water below 60° Fahr. as at warmer temperatures. Mr. Farr appeared to attribute the influence of temperature to the increased amount of vapour and effluvia given off from the surface of the river; but this would not explain the influence of the water on those who drink it.

It may be here remarked, that it would be unreasonable to expect to trace every case of cholera, either through the water, or by contamination of the food; more especially as it is sufficiently probable that the disease may be communicated by cases which proceed no further than preliminary diarrhœa. If the view here given be found to explain more of the progress of cholera the more it is inquired into, it must be held to account for the cases which cannot be traced, in the same way that generation accounts for the existence of plants and animals under circumstances in which we cannot always trace their parentage.

With regard to preventive measures, I entirely agree with the Registrar-General, that "internal sanitary arrangements, and not quarantine or sanitary lines, are the safeguards of nations." For I believe that quarantine would often be evaded, and is altogether unnecessary. The presumed sanitary measures, however, should have a particular reference to the mode of communication of cholera, otherwise they may sometimes be prejudicial instead of advantageous. I have given one instance in the case of Hull, where the malady was nearly ten times as fatal in the late as in the former epidemic, on account of a more plentiful supply of water having been obtained without reference to its quality. In London, the late epidemic was three times as fatal as that of 1832. This was, in my opinion, partly owing to the manifestoes of the General Board of Health, which were understood to imply that the cholera was not communicable or catching in any way; and these documents had an immense circulation, by being copied into the newspapers. The effect was also due to presumed sanitary measures employed both in the interval of the two epidemics and during the late one. In the interval a great number of cesspools had been abolished, and a much larger amount of fæces became daily sent into the Thames, whilst a great portion of the people had still to drink the water; and during the epidemic itself, the flushing of the sewers increased the mischief in two ways: first, by driving the cholera evacuations into the river before there was time for the poison to be rendered inert by decomposition; and second, by making increased calls on the various companies for water to flush the sewers with, so that the water which they sent to their customers remained for a shorter time in the reservoirs before being distributed. It should be remarked, also, that the contents of the sewers were driven into the Thames by the flushing, at low water, and remained flowing up the stream for four or five hours afterwards.

The sanitary measures required for the prevention of cholera, according to the views here explained, suggest themselves at once. They are as follow:—

1. The entire disuse of water into which sewers flow, or which is navigated by persons living in boats, or which is in any other way contaminated by the contents of drains or cesspools.

2. An extended use of hand-basins and towels among the poor, together with sufficient water always in readiness.

3. Strict cleanliness in every one about the patient, or the dead body; and especial care in all such persons to wash their hands before touching food.

4. The separation of the healthy from the sick, and their removal to another abode, when they have no place but the sick room in which to prepare and take their meals.

5. The immersion of all soiled linen in water, until it can be scalded and washed; for if it should become dry, the fæces might be wafted about in the form of dust, and so be swallowed by any one who should come near the linen.

In the way just indicated, it is probable that cholera may be occasionally communicated for a short distance through the air; and when small-pox and other diseases are communicated through the air, it is most likely by organised particles, which are wafted like the seeds of plants and the ova of some animals, and not by anything in the form of gas or vapour. Indeed, there are neither facts nor analogy to show that any kind of epidemic disease whatever can be caused by the air, or even influenced by it, otherwise than indirectly. Epidemics have been attributed to the state of the atmosphere since the time of Hippocrates, and the antiquity of the belief causes it to be received as an indisputable axiom, although our better knowledge of the nature of the air, and of gaseous bodies in general, is capable of entirely disproving it. But the facts which disprove the atmospheric theory of diseases are often pressed into its service, and so handled as to lend it apparent support.

It is a curious circumstance, that the medical men who are most active in advocating the sanitary measures which, as a general rule, would prevent the communication of cholera, for the most part disbelieve in its communicability, probably because the question had never suggested itself to them, except in the form of infection by means of effluvia, or of contagion by contact. What is still more remarkable is, that these gentlemen generally look on the presence of all those circumstances which aid in the communication of cholera, when found in situations where the pestilence prevails, as proofs that it is not communicable. They speak of these circumstances as something which can explain the increased prevalence of the disease without its being communicable, although it has never been explained in this way, even by a hypothesis. One or two hypotheses have indeed been attempted, but have signally failed. One of the most able and experienced authors on cholera writes, for instance, as follows:—"If we could suppose that certain organic impurities existing in the atmosphere of unhealthy neighbourhoods, passed into the blood through the lungs, so as to follow the circulation, and that similar impurities taken into the stomach with articles of food or drink, were likewise absorbed into the blood; if we could, moreover, suppose that the epidemic influence possessed the power of assimilating such organic matter to its own poisonous nature, we should be enabled to include a number of complex phenomena under a hypothesis which would indicate the requisite measures of prevention." The above quotation is from Dr. Sutherland's Appendix to the Report on Cholera; but the latter part of the supposition is quite incapable of being entertained for various reasons, one of which is, that the assumed epidemic influence, in order to be capable of acting in this way, must consist of some material mixed with the atmosphere, and if so, it would diffuse itself through the air, and would also pass along with the air. It could not travel against the wind, or remain in a spot for weeks, without extending to the next parish, when the air is moving at the rate of one or two hundred miles a day.

There is much evidence on the subject of this paper which I had not room to bring forward, and many important points connected with it that I have not been able even to allude to; but I trust that I have succeeded in drawing the attention of the Society to the views I have endeavoured to explain, in such a way that they will be induced to consider the question carefully for themselves.(a)

54, Frith-street, Soho-square.

(a) This paper was originally read before the Epidemiological Society.