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INFECTIOUS DISEASE

AND ITS

PREVENTION.

BY

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PREFACE.

THIS Handbook is intended to give, in a brief and popular form, an elementary account of the origin, behaviour, and means of prevention of infectious disease.

As yet our knowledge of this subject is very incomplete, but each year adds to its store. While, therefore, it has been the object of the writer to avoid as far as possible all matter which is purely speculative, it has been thought well to indicate, although but generally, the lines upon which that knowledge may be expected to grow.

June, 1884.

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CHAPTER I.

ORIGIN OF INFECTIOUS DISEASE.

WRITING more than a century and a half ago of the epidemic of plague which prevailed in his boyhood, Daniel Defoe makes the citizen whose adventures he recounts tell of a madness "which may serve to give an Idea of the distracted humour of the poor People at that Time"—a madness which consisted of "wearing Charms, Philtres, Exorcisms, Amulets, and I know not what Preparations to fortify the Body with them against the Plague, as if the Plague were not the Hand of God, but a kind of a Possession of an evil Spirit; and that it was to be kept off with Crossings, Signs of the Zodiac, Papers tied up with so many knots, and certain Words and Figures written on them, as particularly the Word Abracadabra formed in Triangle or Pyramid." And further, "How the poor People found the Insufficiency of those things, and how many of them were afterwards carried away in the Dead-Carts, and thrown into the common Graves of every Parish."

The time for belief in such superstition is long past, but if the knowledge of our time is to be judged by that of the greater number, it cannot be said that we are free from much opportunity for criticism. Charms have been abandoned, but have not always been replaced by more trustworthy means of protection against disease. We have, indeed, often only exchanged the philtres of 1665 for "some futile ceremony of vague chemical libations or powderings."

The enemy with which we have to contend in our time is not less hostile than in the time of Defoe. It needs but the chances we may give it to compass our destruction. Causing year by year one-fifth of the deaths which occur among us, it is far more to be dreaded than the most terrible of wars: dreaded because "the pestilence that walketh in darkness" is an invisible enemy, and escape from it appears at first sight less easy than from one which can be seen and faced. Nevertheless it is regarded as "preventible" beyond all other causes of death, but for its prevention we must clear away the darkness with which it is surrounded, and by the light of day learn the weapons with which it fights. Before all things we must know our enemy. We must learn how it comes into existence, the material of which it is made, and the manner in which it carries on its war. Then, and then only, shall we be able to bring to bear against it the weapons with which nature has armed us for our preservation.

But it may be asked, How is this knowledge attainable? Many channels of investigation are forbidden to us, and difficulties as a result meet us at every turn. Nevertheless we are not without the means of gaining knowledge, although it comes to us more slowly than if we might arrange a number of carefully thought out experiments. Nature is herself constantly bringing before us experiments of her own creating, but alas, too often under conditions which prevent their true lessons from being learnt, and at a yearly cost of life which is simply appalling. Still many outbreaks of disease require but investigation to tell us how they have their origin. Thus we have learnt in the past, and so we may hope to learn in the future, the various conditions under which disease is caused, and, by the careful study of those conditions, know how disease may be avoided.

How, then, are infectious diseases caused?

We can understand how an unhealthy trade, such, for instance, as knife-grinding, may cause disease of the lungs through the inhalation of irritating particles of dust given off in the process of manufacture ; how are produced those ailments due to wet and cold, or those changes in the tissues which accompany advancing years ; but there is something about the diseases we have to consider which separates them very widely from those which may result from an unhealthy occupation, from exposure to the elements, or from old age. Diseases which can be communicated from one person to another differ very widely from all of these, and in studying them we cannot but be impressed with the fact that in certain particulars they broadly resemble one another.

They do not apparently affect their victim the very moment he is exposed to them ; but there is a period of latency or *incubation* between the time when the poison is received and the appearance of the symptoms resulting from it. They do not last an unlimited time, but within a certain period end in the death or the recovery of the sufferer. Again, the person who comes in contact with another suffering from one of these diseases develops the same disease as that to which he was exposed, and is, as a rule, exempt for the rest of his life from further attack from the same affection, however often he may be exposed to it. Finally, he may, during his own illness, and especially at certain periods of it, impart his ailment to other susceptible people.

Such affections, then, differ very much from all others. They resemble the planting of a seed in a fertile soil. There is, first, the interval when nothing is seen, but during which changes undoubtedly take place, leading eventually to the appearance of a plant upon the surface. This in turn grows, reaches a maximum of development, becomes itself laden with seed, and perishes, but leaving the seed to give origin to a thousand fresh plants wherever a suitable soil may be found for their development.

No particle of steel, no exposure to cold, will give rise to results such as these. Whatever causes such a succession of events must share with the seed one special property: it must above all things possess *life*, a life of its own, not perhaps always active, but always ready to be called into activity the very moment the conditions for its growth can be found.

It was in 1836 that Cagniard de la Tour discovered the yeast plant, and enabled the phenomena of fermentation to be explained by the growth of this organism. When yeast is added to a warm solution of sugar, changes rapidly take place in it, gases are given off, and alcohol is produced in the solution. If the sugar solution be kept free from such organisms, these changes, which we know by the name of fermentation, will not take place; again if the solid particles of yeast be excluded from the sugar solution by a fine filter, or if a solution of sugar containing yeast be boiled, no fermentation will occur. Fermentation only results when the living solid particles of the yeast themselves come in contact with this sugar solution. If the yeast be examined under the microscope it is found to consist of small minute globular or ovoid bodies, each made up of semi-fluid material surrounded by a thin wall. Each of these bodies or "cells" is called a Torula, and it is to the growth of these Torulæ that fermentation is due. When a Torula is placed in a saccharine solution which is kept warm, it throws out tiny buds, which increase in size, and then become separated from the original cell, each in turn producing fresh buds often before they are separated from the parent Torula: thus strings of Torulæ are frequently formed. But no Torula ever exists which has not been produced by a previous one.

For years after its discovery it was not fully recognized that fermentation was due to the *growth* of the plant. It was thought by many that its death was the exciting cause of fermentation. The immediate cause of fermentation had not been understood.

It is now nearly fifty years since the discovery was first made that an infusion of meat could be prevented from decomposing if all the air which was permitted to come in contact with it had been exposed to a flame, and thus the lesson was learnt that the changes known as "decomposition" are really due to something the air contains. At a later stage, Pasteur showed conclusively that decomposition in an organic fluid could alone occur as the result of some organism; and that it was possible by boiling to destroy any living organism or "germ" an infusion might contain, and preserve it from decomposition, so long as all the air which came in contact with it had been carefully filtered through cotton wool, so as to prevent the admission to it of these germs.

Another lesson was learnt when it was shown that these germs might be dried and kept in this condition for long periods of time without losing their vitality, and that they might indeed in some cases be exposed to the action of acids without injury, while in others, if exposed to the same acids, their vitality might be destroyed.

Now the admission of a tiny particle of the yeast plant into the solution of sugar, or of the minutest quantity of a fluid containing the germs of decomposition into an infusion of meat, is sufficient in a very short period to lead these fluids to be permeated throughout with the organism with which they are infected, so rapid is the growth. Again, if other fluids be prepared, entirely free from these organisms, they in their turn can be inoculated in the same way by the minutest particle taken from the fluids previously infected, and so it becomes possible to give origin to millions upon millions of these minute organisms, each of which in its turn, if opportunity be afforded to it, by the provision of a suitable soil, may develop into an indefinite number of others.

To the discovery of the yeast plant we are indebted to a larger extent than it is possible to tell for our knowledge of infectious diseases. When but a few of the facts that are here stated were known, the clear mind of the late Dr. Farr recognized a similarity between the process known as fermentation and the behaviour of infectious disease. Just as the minutest particle of yeast is able to produce changes in a large quantity of sugar, so the smallest quantity of matter taken from the vesicle of a person suffering from small-pox, and placed beneath the skin of another person who has not previously suffered from this disease, and who is not protected by vaccination, is capable of infecting the whole of the body, and covering the skin with many vesicles of the same kind, multiplying the poison over and over again. So Dr. Farr learnt to place together a number of diseases which are caused by the introduction into the body of a something which must undoubtedly have as definite an existence, whether we can see it or not, as the Torula that Cagniard discovered nearly fifty years ago; and to this group of diseases he gave the name of "zymotic," from the Greek *zymosis*, or fermentation.

Since that time the evidence in favour of this opinion has continually grown. In the bodies of those who are suffering from, or who have died from, some of the infectious fevers, are found organisms which there is some reason for believing stand in the same relation to these affections as the yeast does to the changes of fermentation. In the blood of persons suffering from relapsing fever have been found small bodies called *spirilla*, looking like small spiral threads, and capable of movement; and again, in enteric fever and cholera, and many other communicable diseases, have been found certain microscopic organisms. But though complete proof is still wanting for some of these affections that these organisms are the *cause* and not merely the *result* of the disease, it is clearly afforded in the case of two diseases which attack the lower animals. The first, Anthrax, a fatal form of disease amongst cattle and sheep, is undoubtedly produced by an organism which is known by the name of the *Bacillus Anthracis*, and which is found in the blood and tissues of animals which are affected with this disease. This organism appears in the form of minute rods, so small that 1250 of them placed end to end would be required to measure one inch, and so narrow that 18,000 placed side by side would make up the same measurement. They can be removed from the body, and cultivated in an appropriate fluid, and their mode of development has thus been studied. These rods multiply by first increasing in length and then dividing. Bright specks called spores (which we may roughly compare to eggs or seeds) also appear at various points in the length of these rods, and become free when the rods disappear. Although the rods are easily destroyed the spores are very tenacious of life. A few rods or spores introduced into a suitable cultivating fluid will rapidly develop in it, and this may be repeated any number of times, and finally, when the product is introduced into the body of an animal, will infect this creature with the disease, proving that this organism is the cause of the affection. This disease is the more worthy of study for the reason that the same organism, the *Bacillus Anthracis*, is the cause of fatal disease in man.

Again, Dr. Klein has proved by his investigation of the disease which is usually known under the name of pig-typhoid, or pneumo-enteritis, that a specific organism is the cause of this highly-contagious malady. As in the case of the poison of anthrax, he has succeeded in growing it outside the body, again producing the disease when it is once more introduced into the body of a pig.

With regard to both of these affections, as well as ordinary putrefaction and fermentation, we can prove that the cause of each is the growth of specific living organisms, and we can have little hesitation in affirming that the same is also true in the closely analogous cases of other infectious diseases, even in those in which no definite organism has yet been detected. We may leave with assurance to the future the absolute proof for which it is still necessary to wait. Already, therefore, we begin to see that our enemy is a living being, that it preys upon our bodies, and is perhaps in some cases dependent upon them for its own existence; and that every human being with whom it takes up its abode provides the food for its multiplication and growth.

We know that from scarlet fever, scarlet fever alone results; from small-pox, small-pox; from measles, measles. Are we then to assume that every case of these diseases which occurs must have originated in a previous case of the same disease? The experiments of Pasteur have shown that the growth of organisms in the flask is dependent on the entrance of organisms into its contents, but the experiment which can be performed in the laboratory is less easy in the outside world. We shall shortly see that filth and disease go hand in hand, leading many to the belief that dirt unaided can produce infection.

The late Dr. Budd, almost more than any other observer, insisted that every case of infectious disease must owe its origin to a previous case of the same nature.

Recognising that disease is found under all sorts of conditions, but particularly amongst those where filth prevails, he carefully sought for an antecedent case wherever others were to be found, and met with a success which has been encouraging in the highest degree to those upon whom have subsequently devolved similar labours. Just as Pasteur's flasks failed to develop their countless organisms until the admission of unfiltered air carried from without those "germs" which were to act as parents, so the filth which Dr. Budd found in many a cottage failed to give rise to disease until the seed was brought in a manner which through his investigations subsequently became known.

Still we must admit that success does not always attend these efforts, and that there are occasions when antecedent disease cannot be found. In a remote country district where the movements and condition of health of each individual are known, and where there is no reason to suspect importation of disease, infectious sickness will sometimes appear. There are, however, some possibilities that cannot absolutely be eliminated: one is that a person may have suffered from so mild an attack of one of these affections that even his own suspicions are not aroused; another, that one of the lower animals may have been the medium of communication; or again, we are rarely able to exclude the possibility of these "germs," especially of those very persistent varieties which have the power of forming spores, being carried by the wind or clinging to unsuspected articles of food, clothing, &c., and remaining latent for possibly a long period, until they alight upon a suitable soil; for as yet our knowledge of the relation between the diseases of the lower animals and of man is too scanty to enable us to form any other conclusion on this point than that the possibility cannot be absolutely denied.

Wherever importation of infectious disease cannot possibly have occurred, there we find the inhabitants exempt under whatever conditions they are living. Take for instance the freedom of the Faroe Islands from measles; for sixty-five years before 1846 not a single case of measles had been known to exist in these islands. Occupying an isolated position, the probabilities of disease being brought to them from without were remote, and whatever the condition of the islands, it does not appear to have been capable of originating a single case of this disease. Yet, like Pasteur's flask, the material for the development of the disease when once introduced, existed in abundance for in 1846 a sailor suffering from measles was brought into, one of the Faroe Islands and "led to an epidemic which attacked more than 6000 out of the 7782 inhabitants, sparing only the persons who had previously had the disease and 1500 others who were kept out of reach of the contagion."

A similar story is told for another part of the United Kingdom by Mr. John Simon, in the 6th report of the medical officer of the Privy Council: "England has 627 registration districts. During the 10 years, 1851–60 scarlatina, small-pox, and measles were, as usual, prevailing more or less throughout the country, producing among children under five years of age an average annual mortality of 802 per 100,000; i.e., by scarlatina, 419, by small-pox, 103, and by measles, 280. In 626 of the registration districts there were deaths (and, for the most part, in not inconsiderable quantity) from one or more of these causes;

not quite invariably from all of them; for 43 of the 626 (thanks, no doubt, to vaccination) had not any death by small-pox, and among the 43 districts which thus escaped mortality by small-pox, there was one which also had not even a single death by measles; but, with these exceptions, all the 626 districts had deaths from the three diseases—deaths by measles, deaths by small-pox, deaths by scarlatina. But the 627th district had an entire escape. In all the ten years it had not a single death by measles, nor a single death by small-pox, nor a single death by scarlet fever. And why? Not because of its general sanitary merits, for it had an average amount of other evidence of unhealthiness. Doubtless the reason of its escape was that it was insular. It was *the district of the Scilly Isles*, to which it was most improbable that any febrile contagion should come from without. And its escape is an approximative proof that for at least those ten years, no contagion of measles, nor any contagion of scarlet fever, nor any contagion of small-pox, had arisen spontaneously within its limits. I may add that there were only 7 districts of England in which no death from diphtheria occurred, and that, of those 7 districts, the district of the Scilly Isles was one."

It is almost impossible to believe, in face of such evidence, that if filth could create *de novo* the living organisms which we must regard as the cause of infectious disease, that these islands would have escaped for so long a time.

Before leaving the theory of spontaneous origin we must think for a moment of a reason which has been urged on its behalf. Infectious diseases, it has been argued, must at some period of the world's history have had their beginning, and if any circumstances could have given rise to them in the past, there is no reason why the same circumstances might not give origin to them in the present. To this we can but answer with a question of Charles Darwin, are we to "really believe that at innumerable periods in the world's history certain elemental atoms have been commanded suddenly to flash into living tissues?"

The lessons which may be learnt from Darwin must surely apply equally to the organisms of infectious diseases.

How rapidly disease-producing poison may be modified by the circumstances surrounding its existence it is impossible to say. Experimenting with material taken from the abdominal cavity of a dog which had died from inflammation of the peritoneum, Dr. Burdon Sanderson found that, when injected into the abdominal cavity of another dog, the virulence of the poison was rapidly increased, and thus it was possible, by the passage of this material through a number of dogs, to breed a poison which was as intense as that of a snake. So also it is suspected by some that diphtheria will result from a simple sore throat, developing its true characters after passing through successive individuals.

But we have already dwelt enough upon the origin of infectious diseases to show that we have a vital organism to deal with. In some of these affections these organisms have not been found, but it is as impossible to doubt their existence as it would be to question that the growth of a plant must have resulted from the seed of some previous plant. How they originate we cannot tell.

We cannot deny the possibility of disease attacking man through an organism whose natural home is not the body of an animal, for the researches of Tommasi, Crudeli and Klebs have shown us that an organism found in the air and soil of malarial districts, gives rise, when inoculated into dogs, to symptoms of malarial disease, the organism being found situated in their spleens, and Crudeli has claimed to have discovered the same organism in the blood and spleen of man when he is the victim of malarial affections. Malarial disease is not communicated from man to man like measles or small-pox, but the growth of its organism outside the body leads us to think of the poison of enteric fever and of cholera, which exist and have a power of development in water, and which may be communicated from man to man.

CHAPTER II.

CHANNELS OF COMMUNICATION OF INFECTIOUS DISEASE.

WHEN a human being receives into his body infective material and subsequently suffers from any of the infectious diseases, at some stage or other of his illness he gives off the same poison multiplied in quantity an unknown number of times, and capable of giving the same disease to other persons who come within "striking distance" of the poison. But of a number of people who come within this distance not all will become victims to the disease. It is necessary for the germination of the seed that it should fall upon fertile soil, and not every one can provide the soil which is required. The circumstances under which one person is more susceptible to these diseases than another are but imperfectly known, but one fact comes out very clearly with regard to all of them. A person who has suffered from one of these illnesses is to a very great extent protected from subsequent attack of the same disease, however freely he may afterwards be exposed to infection.

What is true for the individual appears also to be true for communities, and thus we are led to believe that protection against infectious disease can be to some extent inherited. As an instance, let us contrast the behaviour of measles amongst European races with that amongst the Fiji islanders.

Measles had never been known in these islands, until their cession to England opened up communication between the islanders and European races, and afforded opportunity for the introduction of disease. In the beginning of January, 1875, the king, Cacobau, returning with his sons and retinue from a visit to Sir Hercules Robinson, in Sydney, where measles was prevalent, brought this affection into the island, one of his sons and his servant having contracted the disease. Measles was also introduced immediately afterwards by one or two other ships, also coming from Australia. The disease first appeared amongst the native constabulary, whose duty it is to board all vessels attacking the whole number, 147 of them, those being first, attacked who boarded the king's vessel. A meeting of chiefs from all parts of the island was held immediately after Cacobau's return, and these subsequently returned to their homes carrying with them the disease which they had contracted. The result was that within four months, of a population of 150,000, 40,000 were dead of measles.

It has been argued, and probably with some truth, that much of this high mortality was due less to the intensity of the poison than to the fact that whole villages being attacked at the same time, there was no one to take charge of the sick, who exercised no control over their conduct and exposed themselves freely to the night air, often lying down in the streams to cool themselves in their fever.

When, however, the behaviour of measles in England is recollected, how numbers of people have but a few days' poorliness, and are not incapacitated from the performance of their daily duties, it does not appear probable that this explanation will wholly account for the difference between the mortality of this disease in England and in Fiji. Measles has existed in England for an indefinite period, and, although very gradually, has weeded out during successive generations those persons who were most susceptible to its influence, leaving the more insusceptible to continue a less susceptible race.

The protection which an individual acquires from having previously suffered from such disease tends to be weakened as time goes on, year after year making him apparently less insusceptible than he was immediately after his first illness. There are some conditions of life which appear to interfere with the protection afforded by a previous attack. The great changes which take place at that period of life which we know as puberty may be reckoned as acting in this manner. Again, it is believed a severe illness of some other kind, or perhaps in woman the birth of children, will bring about the same result. Period of life also has its relation to susceptibility to the influence of infection; children in very early infancy often escape, where those a little older suffer; again, a riper age seems to give protection against attack from one affection, viz., enteric fever, while younger persons contract it more readily.

The inability of the poison to develop in the body of an individual who has suffered from the same disease is limited to that disease alone; a previous attack of scarlet fever protects against scarlet fever only, but not against small-pox, measles, or any other affection. So we may carry our simile of the cultivation of infectious diseases to the growth of seed a further step, and show that the farmer, when he finds the advantages of an alternation of crops, has the same experience of their behaviour which we have of that of these maladies. From this knowledge we must learn one of our lessons in the prevention of infectious diseases. If we are to prevent the extension of any one disease, we ought when possible to permit only those to come in contact with the sick who are themselves rendered insusceptible by a previous attack of the same disease. Prevention of infectious disease must therefore depend upon the avoidance of infection by susceptible persons, and this may be brought about in one of two ways:

A. The prevention of the development, or of the means of communication of the infection.

B. The prevention of the susceptibility.

Although the channels of communication of infectious disease are somewhat numerous, their ultimate end is that they may enter the body in one of three ways: either through the respiratory passages, inhaled by the breath; through the alimentary passages, taken in by swallowing; or through the skin.

By far the greater number of these affections are conveyed in the first way; it cannot, however, be stated positively that the air-borne infection having reached the entrance to the respiratory passages may not eventually find its way into the alimentary canal. A smaller number reach the alimentary canal, through food which may be infected by the excreta of a person suffering from the ailment, or in some other way not yet fully known.

With reference to the third group of diseases received through the skin, it is impossible to say whether this should be limited to small-pox, which is inoculable, or whether it should also include those affections which are also received through the respiratory passages; for without a carefully designed experiment it would be impossible to secure contact of the skin of the recipient with that of the sufferer without the air passage being exposed to infection at the same time, and thus causing uncertainty as to the channel of infection.

What we already know of the manner in which infectious diseases are communicated enables us to roughly classify them as follows :—

Communicated by means of the excreta by air, water, and infected articles.

Cholera.
Enteric fever (typhoid fever).

Communicated by food (milk).

Enteric fever (typhoid fever).
Scarlet fever (scarlatina).
Diphtheria.

Communicated by air, contact with sufferer, or infected articles.

Scarlet fever (scarlatina).
Diphtheria.
Typhus fever.
Measles.
Rötheln.
Mumps.
Relapsing fever.
Whooping cough.
Chicken-pox.
Small-pox.

Diseases which spread through the Excreta.

Our table shows us that there are two diseases in which the poison resides chiefly, if not altogether, in the bowels of the sufferer. It will be better for us in learning how they may be prevented to consider each separately.

The first, *Cholera*, is not always present with us, nor indeed in most other parts of the world; its home is in India, whence it spreads from time to time under circumstances which are still the subject of much doubt and debate. The opportunities for the investigation of the manner in which it spreads in India are surrounded with difficulties in that country, as indeed in our own to a very much less extent. There are a number of persons who every year die from what we know under the name of diarrhœa or English cholera, a disease wholly distinct from that of Asiatic cholera, but presenting symptoms so much like it that it is often difficult to distinguish between the two; hence any attempt to trace the spread of Asiatic cholera is rendered exceedingly difficult in a country where other bowel diseases are always present to a large extent. We shall, therefore, be acting wisely if we learn our lesson from the behaviour of cholera in England, where it is far more possible to trace the affection from one person to another and distinguish between persons suffering from it and those who have other ailments.

During the present century cholera has invaded England on four separate occasions, in 1830, in 1848, in 1853, and in 1865. The late Dr. Snow was led by the study of the second outbreak to believe that cholera was communicated through water, an opinion which received much confirmation from an outbreak which occurred in the neighbourhood of Golden Square in the next epidemic.

The story of the pump in Broad Street, Golden Square, and the way in which it gave cholera to persons in the surrounding district has been so often told, that an apology is almost required before repeating it, but it teaches so important a lesson that it is no matter for surprise that the story is told again and again. It is one of the best illustrations of the way cholera may be communicated by water; for not only did 486 persons living within two hundred yards of the well and drinking the water, lose their lives within eight or nine days, but the water had a reputation for excellence of quality, and was sent for by persons residing at a distance, leading to an outbreak of the same disease in a family living at Hampstead, who happened to consume it. An examination of the well showed it to be contaminated by the drainage of a house in which a case of so-called diarrhœa had occurred. The removal of the pump-handle led to the cessation of the outbreak.

At a later date, in 1865, another well-known outbreak occurred in the village of Theydon Bois, in Essex. Here the disease was undoubtedly brought by a gentleman and his wife who had been staying at Weymouth, and who on their way home were attacked with diarrhœa and cramps, from which the wife subsequently died. Mr. Simon tells us that after their return "within a fortnight in that one little circle eleven persons had been seized with cholera—mother, father, grandmother, two daughters, son, doctor, serving-lad, servant-maid, labourer, and countrywoman; and of those eleven only three survived—the son, a daughter, and the serving-lad; later, in the countrywoman's family there was another fatal case. It cannot well be doubted that the exciting cause of this succession of events was in some way or other the return of the parents from Weymouth; of the father with the remains of choleraic diarrhœa still upon him, of the mother with apparently the beginning of the same complaint; but this is only part of the case, and the remainder teaches an impressive lesson. All drinking-water of the house came from a well beneath the floor of the scullery, and into that well there was habitual soakage from the water-closet." *

* Eighth Report of the Medical Officer to the Privy Council.

The outbreak of cholera in 1866 will be in the memory of the majority of those who will come to read these pages. It will be recollected that London did not suffer equally over its whole area, but that the eastern part of the metropolis was attacked more severely than other parts. The explanation of the disaster was due to Mr. Netten Radcliffe, who investigated the outbreak ; he found that the disease began amongst those who received their drinking water from the mains of the East London Water Company, that this company was in the habit of drawing its supplies from the river Lea, and that owing to a defective supply from its filter beds, it had drawn its supplies from a source which was known to receive the drainage from a number of houses. At this time two men who had come from Rotterdam took up their abode in one of these houses, where one or both were attacked with cholera, the pollution of the river by their excreta furnishing an explanation of the subsequent outbreak. As confirmatory evidence that the water of this East London Water Company was the cause of the disease, may be cited the escape from attack of the pupils resident in a school situated in the middle of the infected area, but having a well of their own from which alone they received their drinking water.

The same kind of evidence has been found over and over again ; in Scotland Dr. Stevenson Macadam showed that the propagation of cholera resulted from the pollution of drinking water, and that the disease ceased when a pure supply was obtained. So again, Dr. De Renzy pointed out that where sanitary improvements in India had taken place which had not included the provision of a pure water supply, there the mortality from cholera was not affected. Later, we have Dr. Koch, the chief of the German Commission, now engaged in India, finding in the intestines of human beings who have died from this disease, an organism which he believes to be intimately associated with its production, and further finding these organisms in a tank in the village of Sahib Bagau, a suburb of Calcutta, where an epidemic of cholera was in progress. The water was used by about one hundred persons living near, of whom seventeen died, and its use was not limited to supplying drinking water, but served the inhabitants for purposes of bathing and washing, and in it the linen of the first fatal case of cholera was washed. The organisms were found in greater number in the first sample of water collected, becoming less numerous as the epidemic declined.

It has been more than once asked how water once polluted in the manner we have described, ever becomes again free from infection. As yet such a matter can be ground for speculation alone, but any difficulty which may be felt in finding an explanation for the subsequent freedom of water from infection certainly should not stand in the way of a willingness to accept such evidence of its pollution as already exists.

There is also evidence that cholera can be conveyed by air. It will easily be understood that unless the excreta are carefully dealt with there is risk of such an accident happening by their being blown from their place of deposit or from soiled linen towards susceptible persons. In 1866 an outbreak in the City of London Workhouse was attributed by Mr. Netten Radcliffe to the air from a sewer containing cholera excreta.

Another method by which the contents of the alimentary canal of a person suffering from cholera may cause disease is well illustrated by a story told by Brigade-Surgeon J. B. Scriven. Dr. Scriven was, while in India, called to a case of cholera in the person of a young child who was being attended by its father, mother, and several other women. Dr. Scriven cautioned these people against the risk of permitting any of the discharges from the child to come in contact with their lips; while he was doing so, he noticed that the father persisted in kissing the child, and one of the women was wiping her mouth with a handkerchief which had been used for the child's face. Subsequently both these persons were attacked with cholera, the father dying, and they were the only members of the whole group who were attacked. It cannot be doubted that the disease was conveyed in this manner from the patient to its attendants.

Enteric fever, the second disease which is spread by the excreta, is communicated in the same way as cholera, that is to say through the poison being conveyed by water, by air, or by infected linen, or the hands of attendants, as already described by Dr. Scriven. It is moreover also conveyed through milk, but of this we shall speak more in detail later.

Instances have occurred over and over again in which drinking water has been the channel by which the poison has been introduced into the bodies of those who have contracted the disease. There is no better example of the direct infection of drinking water than that afforded by the outbreak of enteric fever in the Caterham Valley in 1878, which was investigated by Dr. Thorne of the Local Government Board. Dr. Thorne found that forty-seven persons had been attacked with enteric fever in the fortnight ending February 1st of that year ; the disease was not confined to any special class of houses, those belonging to both rich and poor having suffered alike. By far the majority of the houses drained into separate cesspools, therefore no common system or drainage could be held responsible ; it was further found that thirty-three of the houses affected received their milk from at least five different and completely independent dairies, and that at the remaining two private cows were kept ; milk therefore had nothing to do with the cause of the disease, and it was also evident that personal infection could not have led to the outbreak. Until this time Caterham had been very free from enteric fever ; it was observed that of the forty-seven persons attacked during the fortnight, forty-five resided in houses where the water of the Caterham Waterworks Company was in use ; the other two were known to have drunk the same water elsewhere. It was also observed that the Caterham Asylum, containing 2000 patients, and the Caterham Barracks, where 500 men resided, had entirely escaped, and both these institutions had independent water supply from deep wells.

At the same time the neighbourhood of Redhill was also invaded by the disease; in Redhill are 1700 houses, of which 924 received water from the Caterham Waterworks Company, and of 96 houses affected during the same fortnight, 91 drew their water from this source; of the remaining five the inmates had been also known to have drunk the same water. Additional evidence was also obtained by Mr. E. L. Jacob, the medical officer of health to the district, which proved conclusively that the water was the cause of the disease, but the manner in which it became polluted was not at first obvious, probably it would never have been discovered if previous knowledge had not already taught that these diseases do not arise *de novo*. The explanation was, however, at last forthcoming; some work had been going on in one of the wells of the Waterworks Company which required men to enter the well, and one of these thus employed went through an illness which there can be no doubt was enteric fever. It was proved in the clearest manner that the well water was polluted under these circumstances, and it is interesting to observe that the occurrence of enteric fever amongst the drinkers of the water took place a fortnight after the pollution of the water began, this fortnight representing the usual incubation period of the disease.

One other example of the spread of enteric fever by water may be referred to, that of the outbreak in Caius College, Cambridge, in 1873. This instance is particularly instructive on account of the certainty with which were substantiated the conclusions arrived at, and the method by which the disease was disseminated.

The investigation was conducted by Dr. Buchanan, now Medical Officer to the Local Government Board, and showed that while there was some amount of enteric fever in Cambridge, there was a special incidence of the disease on Caius College, and especially upon the students occupying rooms in Tree Court. The College was supplied with water on constant service, and while every water closet in the other part of the building was provided with a cistern proper to itself, those in Tree Court buildings received water direct from the high-pressure constant-service water pipes. The pipe which supplied the pan of the water closet also sent a branch or weeping pipe to a small trap in the safe, which received any splashings from the pan, and was so arranged that this trap received a supply of water at the same moment as the pan. A water valve was provided which was intended to prevent the return of any air or fluid either from the pan or the small trap into the water pipe.

Dr. Buchanan ascertained that on certain occasions the pressure of water had not been maintained in the mains, and that a back current must have taken place as the result; also that the small trap was liable to pollution from splashings from the larger trap, that the water valve could not be relied upon, and that chemical analysis of matter found at the end of the weeping pipe proved that excrementitious matter had absolutely been sucked up into the water main and thence been distributed to the pipes supplying water for drinking purposes.

Proofs of the production of enteric fever by pollution of water supply are of constant occurrence. Every year adds to the list of cases to which reference might be made. The report of the Medical Officer of the Local Government Board just issued, gives an account of a serious epidemic of enteric fever in Bangor in 1882, in which nearly six hundred persons, out of a population of ten thousand, were attacked with the disease, the outbreak being traced to the infection of a stream supplying water to the town. Nor must we forget to make mention of the spread of this disease to 113 persons who drank lemonade and eat ices at a regatta, the water from which these were prepared coming from a well which was shown to be liable to contamination.

That air, too, may under certain circumstances act as a carrier of infection, will of course be readily seen. Dr. W. B. Carpenter writes of an outbreak which took place in a large and airy house standing by itself in a salubrious situation, and in which four members of one household were attacked with typhoid, the particulars of which he had the opportunity of learning on the spot. "The most careful examination failed to disclose any defect in its drainage or its water supply. There was no typhoid in the neighbourhood, and the milk supply was unexceptionable, but the neighbouring house being old, and having been occupied by a school, its removal had been determined on to make way for a house of higher class, and as the offensive odour emanating from the uncovered cesspool was at once perceived in the next garden, and the outbreak of typhoid followed at the usual interval, the case seems one which admits of no reasonable question." *

While air can thus convey the poison of enteric fever it does not appear to do so in any other way than by the carriage of infection from the excreta. In a hospital ward, well ventilated and kept in a proper state of cleanliness, disease does not spread to other patients if a person suffering from this fever be introduced amongst them unless they come into such close contact as would admit of their hands becoming soiled with infectious material which may subsequently be conveyed to the mouth, an accident which from time to time must happen amongst nurses unless great care be exercised.

Contact appears to be required for the extension of enteric fever, either with the patient or his discharges ; but when this occurs, the spread of the disease will, even in well arranged hospitals, occasionally result.

Dr. G. C. Henderson, now of Jamaica, who was, until lately, Assistant-Physician to the London Fever Hospital, when acting as medical officer to another institution, had under his charge a ward in which were placed persons suffering from affections other than fever ; into this ward was admitted a woman who was passing through an attack of enteric fever, and who was placed in a bed amongst the

* The Germ Theory of Zymotic Diseases. *Nineteenth Century*, February, 1884.

others. During an alarm of fire, the delirious fever patient left her bedroom, and sought refuge in that of another patient, with whom she was in contact for a few moments, and who was the only one of some fifteen or twenty who subsequently contracted the disease.

Again, in a house in Kentish Town, there lived during last year, three families, consisting of six adults and two children on the first and second floors, and two adults and six children on the ground-floor. First a child living on the ground-floor died of a disease lasting three weeks; but which the father described as the "fever." When the infant died, the mother and two other children, of the same family, took to their bed with an attack of enteric fever. Nine days after, a fourth child of the same family sickened with the same disease, a week later, a fifth child, and shortly afterwards, a sixth. The excreta were thrown down the one watercloset of the house, which was situated immediately outside in the backyard; the water-closet was also used by the eight other persons residing in the house, of these all escaped but one, and this one was one of two who tended the sick in the room below during their illness.

Here only those contracted the disease who came into close proximity and even contact, with the sick, giving opportunity for disease to be conveyed, as in the cases mentioned by Dr. Scriven.

Only a few months ago the writer, in endeavouring to ascertain how enteric fever had come to make its appearance in a house in the parish of St. Pancras, was perplexed by at first finding no direct cause for its existence. Enteric fever had recently been widely disseminated through an infected milk supply, and a woman living in another part of the district had been attacked as a result. Her sister, whose illness subsequently became the subject of investigation, had not for some time before, or during the illness, had any communication with the first case, nor had she been exposed to the same condition which had given rise to it. Her own illness only came to be explained when it was found that the mother of both women had brought to the second house linen soiled with the discharges of the first case, and that she had been employed in washing it.

A similar instance is quoted by Dr. Thorne, as having been recorded by Dr. Gilbert Child. A family living in a village in Oxfordshire, consisting of a woman and her son, were joined on November 20th, 1873, by another son, who brought with him "several boxes of very filthy bedding, clothes, &c." On the 29th his brother was attacked with enteric fever, and afterwards died, and on the following day his mother also fell sick of the same disease. The cause of infection could not be ascertained until it was found that he had brought with him the dirty bedding and clothing of his wife, who died of enteric fever in the previous September, in Toronto. But one other case of enteric fever occurred in the village, that of a woman who was attacked on December 5th, and who had been employed in washing the dirty clothes.

Time does not always appear to diminish the potency of the poison, numerous instances are recorded in which a house has retained infection for years. Thus Dr. Thorne writes, "I know a detached house which stands in large grounds in a country district, and which was occupied by a groom and his family, amongst whom enteric fever prevailed in the autumn of 1872, one case being fatal. This family continued to occupy the house for nearly two years after this occurrence; but they left it some time in 1874, in consequence of the departure of the owner of the estate on which it stood. From that date, the house remained unoccupied until February, 1876, when it was tenanted by new inmates, and exactly within fourteen days of these latter taking up their abode there, enteric fever broke out amongst them, and a most careful inquiry led both the medical men in attendance and myself to the conclusion that the disease was not imported.

So far as we have as yet gone, the two diseases, cholera and enteric fever, spread under conditions which are practically identical, conditions which always include the conveyance of the excreta, or of some poison derived from the excreta, from a person previously infected with this disease, to those who subsequently develop it ; but in the latter affection, our knowledge has gone a step further, we have learnt that the poison may be conveyed not in water alone, nor by air alone, but by a common article of food—*milk.*

Diseases which spread by Milk.

Since Dr. Ballard first traced, in 1870, an outbreak of enteric fever in Islington to a particular milk supply, and directed attention to this mode of propagation of disease, a number of other outbreaks have been clearly proved to be due to the same source. In the Islington epidemic, and again at a later date in Marylebone, when another outbreak occurred, there was considerable reason for believing that the milk became contaminated by means of polluted water used for washing the milk pails—water previously contaminated, at any rate in the latter instance, by excremental matter from a person suffering from enteric fever. Without doubt milk would afford an excellent growing ground for the development of an organism which has the power of self-multiplication in water, and given the introduction of the poison, even in the smallest quantity into the milk, its further development and influence upon the milk-drinkers is easily understood. But the absence of evidence of such contamination is not infrequent, so much so, indeed, as to lead to the suspicion that milk may come to cause enteric fever under some other circumstances than the addition to it of the typhoid excreta of man.

In writing, therefore, with such knowledge as we now possess, we must not assume too absolutely that the extension of enteric fever through an infected milk supply must have necessarily resulted from its contamination with the excreta of man, although such contamination, when it does occur, is an ample cause of disease.

There is another reason for keeping our minds open on the question of the manner of infection of milk with the poison of enteric fever. This is not the only disease which is propagated by milk; there are two others which are certainly spread by this means, and in these, it is important to note, the poison is *not* known to reside in the excreta of those suffering from them. We refer to scarlet fever (scarlatina), and diphtheria. There is a complete absence of any proof that the poison of either of these diseases has been conveyed by drinking water, as in the case of cholera or enteric fever; wherever there have been large outbreaks of either scarlet fever or diphtheria, they have resulted from personal communication between one person and another, or by means of infected milk.

That scarlet fever could be caused by infected milk was first discovered by the late Professor Bell, of St. Andrew's, who investigated an outbreak of scarlet fever in that town in 1870, and believed that the milk became infected by the milk carrier and her children, who were suffering from this disease.

Other epidemics have been shown very conclusively to be due to this cause, as one of recent date may be mentioned, that in Bloomsbury in 1883, which was investigated by Mr. Power of the Local Government Board, and Mr. S. R. Lovett, Medical Officer of Health of St. Giles'. In this case it was shown that the milk coming from a particular dairy in St. Giles', was responsible for the disease in that neighbourhood, and in St. Pancras. The milk was received by the dairyman from a farm in Surrey, some portion of it also being distributed in the parish of Camberwell, where it was received direct from the Surrey farm. In Camberwell there was a similar incidence of scarlet fever upon the milk-drinkers that was found in St. Giles' and St. Pancras, while, as further evidence that the milk was infectious on leaving the farm, it was found that among the families of six railway servants who received some portion of the milk at Charing Cross, thirteen persons were attacked by scarlet fever or throat affections, about the same time as the milk-drinkers in the other parts of London referred to.

Inquiry at the farm, however, proved that "it was practically out of the question that the milk at the farm had become infected in any of the commonly believed ways that required a human subject as the source of infection." Here then is another instance of disease starting from milk, but giving no sign of how the milk became infected. It is not our intention to trespass too much upon theories which must necessarily be speculative; but we would desire to refer in the briefest way, to a matter which may in the future, throw light upon this and other epidemics. Amongst the cows supplying milk on this farm, Mr. Power observed that one of them had recently calved. This was practically all, but the observation has led to certain experiments being performed by Dr. Klein, which tend to prove that if a cow which has recently calved is inoculated with matter taken from the throat of a person suffering from scarlet fever, she is affected by an ailment "which is transmissible, after the manner of an acute specific disease, to pigs."

Whether the cow without such inoculation can suffer from scarlet fever, the future alone can show; but in view of the possibility of her inoculation at this period, it is certainly important that her milk at such time should not be used for human food.

The story of diphtheria spread by milk in many respects resembles that of scarlet fever; in two or three outbreaks it has been very clearly proved that the disease was disseminated by milk. Our lesson may be best learnt from one occurring in 1878, when over 200 persons were attacked in North London; the epidemic was also investigated by Mr. Power, who showed first that the milk was the means of the communication of the disease, and secondly, that there was very strong reason for believing that the milk had not been infected after leaving the cow.

More recently an epidemic prevalence of sore throat at Dover has been attributed by Dr. Robinson to a milk supply coming from a dairy, receiving milk from three farms, in one of which the animals had recently suffered from foot and mouth disease.

Milk, then, may perhaps be a means of communicating not only the ailments of man to man but also of cow to man, and in laying down rules for their prevention, we must have regard to this fact.

Diseases which spread by Air, by Contact, or by Infected Articles.

But while we have mentioned one method by which scarlet fever and diphtheria are conveyed to man, we have yet to tell of others which are doubtless far more common. Such are infection by direct contact with the patient, or at a distance by means of air poisoned by emanations given off by the breath or from the skin, or by infection of linen or articles of clothing by mucous discharges from the nares and throat. One or other of these methods is the ordinary channel of communication of all the remaining infectious diseases, viz., typhus fever, measles, rötheln, mumps, relapsing fever, whooping cough, chicken-pox and small-pox. None of these affections are known to be communicated through the excreta or food, but only by contact with the sufferer, or by infected air, or infected articles.

It is a common experience to us all to find diseases spreading in this way. If any person is attacked with one of these affections, he is liable to infect first of all those who are in attendance upon him ; he will give infection also to the bed in which he lies, to the curtains, the carpet, and also to the room in which he dwells; so that those susceptible persons who may come in contact with these articles or enter the room may themselves become victims to his disease. Or further, he may so infect the air of his apartment that it may escape from the room, and thus carry disease to those who have never entered it. He is, indeed, during his illness constantly sowing seeds which have but to find a suitable soil in a susceptible person for their development.

When we contemplate what must be taking place as the result of every case of infectious disease, it is indeed a matter for surprise that these diseases do not spread more rapidly than experience teaches us they do.

Infection, then, may be conveyed from the sick to the healthy by persons who do not themselves suffer from disease; the carriage of infection by third persons is a possibility which has to be considered. A nurse in a fever hospital known to the writer, was a melancholy instance of this power of carrying infection. The hospital wards were at the time to which we refer occupied by numerous cases of typhus fever, and this nurse's exposure to the infection was of a most intimate character. She had long before suffered from typhus herself, and was not therefore susceptible again to its influence, and she felt that she might with safety to others spend a short holiday with friends in the country. Her story, as told by herself, is that she was careful to change her clothing, and take such other precautions as she thought to be necessary, but there is no doubt that she took to a farmhouse situated in a remote rural district her box and clothing which had been in the fever hospital. Shortly after her arrival several of the inmates of the house sickened with an illness which soon proved to be the same fever she had been nursing at the hospital, with the result that two of the sons of her host died. So the writer has known small-pox and chicken-pox, and scarlet fever and measles, to be conveyed from one ward to another in hospitals.

Articles of clothing when once infected may retain the infection for a long period; often the removal to hospital of an infectious person is rendered of no avail owing to the fact that some infected garment has escaped observation, and has been put away until some occasion for its use has led to the re-appearance of the disease. For instance, the writer recollects a child being removed to hospital with a view to preventing his brothers and sisters contracting scarlet fever from which he was suffering; considerable care was taken to prevent him, on leaving, from taking away anything he had had during his illness. Some time after this, during the removal of the family into another house, his mother noticed a toy, which had been in his possession while ill, in the hands of a younger brother who had until then escaped. Within a few days this child sickened with the same disease and shortly afterwards died. The toy must have retained for a long period the infection, which had only awaited its opportunity for the production of a fatal disease.

Other instances are on record, that scarlet fever poison may thus remain dormant for more than a year without losing its power.

Writing of diphtheria, Dr. Thorne refers to instances which came under his own notice, in which the facts warranted the conclusion that the poison of diphtheria had been retained for months about premises in which cases of this disease had previously occurred.

These cases need not excite our surprise when we recall to mind the story told of wheat taken from the coffin of a mummy, where it had been placed some thousand years before, and which was yet found capable of propagation after all this lapse of time.

But at what period of the disease does the sufferer first become capable of imparting infection? We have said that from the moment the poison is received until the appearance of the first symptoms, there is an interval of time or period of incubation in each of these affections. There is much reason for believing that during this period the poison is not given off. This is best shown when a child ill with measles is accidentally admitted into a hospital ward where are other children who have not previously had the disease. If he remain there only for a few hours, he will likely enough have infected some number of those in the ward with him; his disease is then recognized and he is removed to a place where he can do no further harm, but those whom he has infected will in their turn some eight or ten days later develop symptoms of the disease, and become a source of danger to others in the ward. Again in their turn these will be removed as soon as the disease is recognized, but not before they have imparted infection to some proportion of the remaining children, who will not sicken till about the same period has elapsed.

Now if the first group of children had been giving off infection while they were incubating the disease, we should not have had a second group attacked almost simultaneously eight or ten days after the first group sickened, but should have found the second series occurring at irregular intervals over the whole of the preceding period. Later on, this marked evidence of the incubation period gradually becomes lost, owing to the period not being absolutely fixed, and owing also to the non-removal of the children the very moment they sicken.

The writer has had the opportunity of witnessing this behaviour of the infectious diseases in the case of three separate affections, chicken-pox, measles, and small-pox, and there can be but little doubt that the other affections resemble those for which this fact has been observed.

We may take it, then, for all practical purposes, that the power of imparting infection begins with the first symptoms and lasts until the patient has absolutely recovered, and by recovery we must mean not only that he shall feel well, but that we shall not deem him recovered until all those special appearances of his disease shall have disappeared, which we shall presently describe.

These two periods have such important bearings upon the prevention of infectious diseases, that it will be well to arrange them in a tabular form so that they may be better understood.

There is much difficulty in learning the exact incubation period of disease, owing to the comparatively few opportunities which occur for eliminating extraneous sources of infection. For instance, a child may develop scarlet fever, and it may be known that some time before she was in contact with another child living in a house where scarlet fever was present. Are we to assume that this meeting was the cause? We could only do so with certainty if it were possible entirely to exclude all other chances of exposure to infection. In large towns, where there are always a number of persons suffering from this malady, it is impossible to be sure that infection has not been encountered at some large gathering, such as at school or at church, in the train or omnibus, or that infection has not been received in some other of the ways already indicated. We have to seek our most reliable evidence in sparsely populated districts, where the condition of health of every one can be accurately ascertained. The same difficulties meet us in our efforts to determine the length of time during which persons suffering from the various infectious diseases remain a source of danger to others, but it is believed that the statements contained in the following table are approximately correct. It must, however, be recollected that the duration of infectiousness varies much in different cases.

TABLE I.

Name of Disease.	Usual Period of Incubation.	Average Duration of Infectiousness.
Cholera . . .	1 to 5 days.	2 or 3 weeks.
Enteric fever .	8 ,, 14 ,,	6 ,,
Scarlet fever .	1 ,, 6 ,,	6 ,,
Diphtheria . .	1 ,, 8 ,,	6 ,,
Typhus fever .	6 ,, 14 ,,	4 ,,
Measles . . .	8 ,, 20 ,,	4 ,,
Rötheln . . .	6 ,, 14 ,,	3 ,,
Mumps . . .	14 ,, 22 ,,	3 ,,
Relapsing fever .	2 ,, 16 ,,	4 ,,
Whooping-cough	4 ,, 14 ,,	8 ,,
Chicken-pox . .	10 ,, 14 ,,	3 ,,
Small-pox . .	12 days.	6 ,,

The use to which we must put our knowledge we reserve for another chapter, but we must not omit to point out here that these diseases are not all equally infectious at their beginning; that measles is undoubtedly infectious, and in a high degree, before the appearance of the rash, and before therefore the malady can be recognized, while scarlet fever is less infectious in the early stage, and the earlier appearance of the eruption enables it to be identified before it has always had time to do mischief; that whereas a brief exposure to measles, small-pox, chicken-pox, scarlet fever, and mumps, will often suffice for the communication of the disease, as a rule typhus is not contracted until the recipient of the poison has been exposed to it for a longer period. There are of course many exceptions to this rule. The writer has known a medical man to be daily engaged for some six weeks in attendance upon over a hundred persons suffering from scarlet fever, in different stages of the disease, before contracting it himself; and has, on the other hand, known a group of three nurses to contract typhus fever after but a day or two's exposure to a single case.

CHAPTER III.

MEANS OF PREVENTING COMMUNICATION OF INFECTIOUS DISEASE.

HAVING made ourselves acquainted with the manner in which infectious diseases are communicated to man, we must give our attention to the ways in which this communication may be prevented.

From what has already been said, it will be sufficiently obvious that no single rule can be made for all affections, for while some have one method of attacking man, others have another, and our means of prevention must therefore have relation to the method of attack. Broadly speaking, all are dependent upon want of cleanliness, or, to be more exact, upon "the presence of matter in the wrong place," for the dirt with which we have to deal is not mere débris of lifeless matter, but contains a vital organism. There is no doubt that the waste material of the body even in health is itself a ready source of disease, but of a kind with which it is not our business to concern ourselves. The matter which may cause infectious disease is its companion rather than its result, for where the one is found there may the other be also; not depending upon it for its first presence, although perhaps under some circumstances developing readily in it. The dust which hangs about the house may have with it the germs of scarlet fever; the dirt which soils the linen may contain the poison of enteric fever; and again, the filth that fills the cesspool may not only receive the poison of the same disease, but may provide for its growth and increase. The enforcement of cleanliness is, therefore, the prevention of disease, and especially of some of those diseases whose poisons may grow outside the body. These, from the fact that they are discharged from the body with the excreta, are more closely associated with uncleanliness, and are indeed known, with others, as filth diseases.

While, therefore, we may hope, in our association with our fellows, by care to avoid some of the infectious diseases, for others, enteric and cholera, special precautions will be required, and these are means for the enforcement of cleanliness.

For the prevention of these affections the doctrine of cleanliness cannot be too earnestly preached. The pollution of houses, the saturation of the ground, the contamination of the air and water which result from habits of slovenliness and ignorance, are daily causing the deaths of numbers of persons. Every circumstance which gives opportunity for the pollution of air, earth, and water is fraught with danger to mankind. Within the house the fittings of water-closets and drains must be so arranged as to render this impossible, and beyond the house the same precautions must be taken ; thus, while we condemn the defective drain, which permits its contents, both gaseous and fluid, to escape beneath the house, so we must equally condemn the faulty sewer which leads to the retention of filth within it, and the cesspool, which is simply an opportunity for the preservation of the material upon the destruction of which our safety depends. Under no circumstances can the cesspool be defended. By this system we are absolutely surrounding ourselves with storages of poison, which may at any time deprive us of life ; for the air we breathe may thus become laden with the fatal poison, and we are exposing to the chances of contamination the water upon which our lives also depend. In some way or another the water we drink comes from the earth, and if the poison is stored beneath the surface, it will undoubtedly at some time find its way into the well or the stream.

Just as at Theydon Bois, cholera destroyed three-quarters of a household, and as at Bangor, more recently, enteric fever infected the whole district, so we shall always have disease and death amongst us so long as we expose our drinking water to excremental pollution. Nor is there any need for the risks which are daily incurred by a large number of the population, for the means of safely disposing of the waste material of life are within the reach of all.

It would be beyond our province to enter in detail into the various modes of dealing with excremental matter, but we may briefly touch upon those requirements of health which must be held in view if we are to escape disease.

Wherever there is a water-carriage system we are exposed to danger from the sewer, for it must necessarily at times, through its communication with a number of houses, receive poisonous material giving off emanations which, carried into other houses, would expose the inmates to risk. The drain of the house must therefore be aërially disconnected from the sewer. This can be effected by the use of proper water-traps at both ends of the drain, at its entrance to the sewer and below each opening in the house. These will, if the sewer be ventilated so as to prevent any undue pressure within it, effectually guard against the admission of air from the sewer into the house. But this is not quite all ; the presence of a closed cavity, such as the drain then becomes, may itself be a source of danger, for not only will the air of this cavity become charged with emanations from effete matter constantly passing through it, but the reception of hot water into it will so expand its air-contents as to cause them to pass through the traps and enter the house. This air-space then must be ventilated, and this is best done by the continuance above the roof of the soil pipe. Still even with this arrangement all our difficulties are not overcome, for the air in the drain will practically remain unchanged and will gradually charge the water in the traps, which in turn by evaporation from its surface, or by the bursting of bubbles, may discharge into the air of the house the poison which it contains. It is therefore necessary not only that the water in the traps should be changed by flushing, but that its pollution should be rendered impossible by the maintenance of a current of fresh air through the drain, and this can only be effected by the provision of another ventilating opening at its lower part, before it enters the sewer.

In this manner we may protect our houses from the admission through the drainage of infection from without.

If there be no water-carriage system, recourse must be had to a dry method for disposal of the excreta. Receptacles sunk beneath the earth should be avoided, seeing that pollution of the ground is more likely to take place with such an arrangement than with others. The object to be held in view is the temporary deposit of the excreta in such a place and in such a manner that they may not give rise to any emanation which may enter the dwelling, and may be speedily and regularly removed therefrom. The receptacle, therefore, should be placed away from dwelling rooms and well provided with ventilation into the external air; and, to give facilities for the frequent removal of the contents, should itself be movable and of small size. The pail system is that which best meets the requirements of health, and where earth can be used in connection with the pail, the best results are obtained. Upon the subsequent disposal of the pail contents we need not enter, except to insist that whether this be done by a town authority or by the householder the same precautions shall be taken. Excreta may be manufactured into manure or used over land for the same purpose, but no storage must be permitted where it becomes possible for injury to health to ensue.

We have still to face the risk that some member of the household may contract disease elsewhere and develop it at home. What precautions must then be taken to prevent its extension?

To prevent the spread of infectious diseases we must rely in the first place upon *isolation and disinfection;* and by isolation we mean the separation of the sick from the healthy, so long as the former is capable of imparting his disease. If isolation is to be of the greatest value it must occur before the sufferer has already infected others. We have already stated that the infectious diseases are not equally communicable during their whole period, and that they are not alike infectious in the earlier stage; thus, there is a greater probability that some diseases will have been communicated to other people by the time the disease is recognized, than is the case with the rest. Let us first consider the case of measles, which is so highly infectious in its early stage, even before the eruption makes its appearance, that in all probability if the sufferer have been in close contact with other children, the latter have become infected before isolation can take place. In considering then what shall be done if infectious disease appear in a family, thought must be had for the isolation not only of the individual who is already attacked, but of those who may be incubating the disease, and particularly when the disease is, like measles, very infectious in its early stage. This is of especial importance when the question comes to be decided whether the sick shall be sent away from the healthy or the healthy from the sick, for if the latter, although showing no signs at the time, are already infected, they may by their removal to another place, become fresh centres for the distribution of disease. Taking as our example of an affection very infectious in its early stage, the disease to which we have referred, and supposing one member of a young family were attacked with measles, which would obviously only come to be recognized as measles on the appearance of the rash, should we be acting wisely in recommending the distribution to one or more other places of the remaining children who will have had such contact with the sufferer as must always take place where a few children, who are brothers and sisters, live together in the same house? The question can only be answered if regard be had to other considerations; if the other children could be removed to a home where they may subsequently develop the disease without exposing fresh children to risk of infection, there can be no objection to such removal taking place, although no great promise can be held out that good will result from such a course. The convenience of the family in making arrangements must therefore be studied. But the alternative plan will suggest itself of removing the sufferer to some place where he can do no harm: is this a better course? Here again, the same possibility must be held in view: the mischief is probably done before the removal can take place, and the suggestion should therefore be only acted upon when this is thoroughly appreciated. Speaking generally, if isolation from those already exposed to measles is to be attempted, it is not worth while that it should not go beyond an effort to retain the sufferer in a room apart from the other members of the family, with such other precautions as will afterwards be described.

With mumps and whooping-cough the facts are very similar. We have no rash to wait for here, and in the latter the bad cough from which the child is suffering rarely comes to be recognised as whooping-cough before the other children have become its victims.

But having said this much, we would wish to point out very clearly that the separation of persons who have not been exposed to infection of these ailments from those who are suffering from them, stands in very different relation to the separation of those who have already been exposed, and all proper precautions should be taken to prevent contact between healthy, susceptible persons and those who are infectious, from whichever of these diseases they may be suffering.

While we have dwelt upon the drawbacks attendant upon the isolation of persons suffering from diseases such as measles, whooping-cough, and mumps, which are infectious at an early period, we would wish particularly to distinguish between these and other affections less communicable at this stage. Innumerable instances could be given of one member of a family being attacked with typhus fever, scarlet fever, and diphtheria, whose removal from the house was the means of ensuring the safety of the rest of the household. If on the first appearance of the characteristic symptoms of these affections the sufferer is at once isolated, there is every reason to hope that the further extension of the disease will be prevented.

Between these two groups come the other diseases: these are undoubtedly infectious at the beginning of illness, although less so than measles.

The most complete isolation is accomplished by the removal of the sick to a hospital, and this is essential where the disease is of a character likely to endanger life, and especially where more than one family occupy the same house. Chicken-pox, rötheln, and mumps are affections so little dangerous to life that isolation is more a question of convenience than of necessity, but for graver diseases the need is much more urgent, and complete isolation should be rigidly enforced.

If removal to hospital be impossible, it is necessary to isolate the sufferer as completely as possible at home. He should be placed in a room at the top of the house, unless equally well isolated rooms can be found elsewhere, and be confined to the one or two apartments he is to occupy during his illness. The Society of Medical Officers of Health have recommended that a sheet soaked in a proper disinfectant should be hung over the door of the room, with a view to preventing the passage of infected air into other parts of the house. The windows both of the sick-room and adjoining passage should be kept open, so as to ensure thorough ventilation. From the room itself should be removed all unnecessary furniture, as well as curtains and carpets, unless it be proposed to destroy these at the end of the illness. If chests of drawers and cupboards are retained, they should be emptied of their contents, nothing being kept except what will be required by the patient. The carpet on the passage and stairs leading from the sick-room should also be removed, so that it may not be exposed to infection. The attendants should be selected from those who have previously passed through an attack of the disease they are called upon to nurse, and who are thus less liable to contract it again. They should be prevented from coming in contact with those who are not already protected, and the room they occupy must be avoided by such persons. It would be well for their dress to be made of some material which can be readily washed and disinfected, and should not, therefore, consist of woollen material. The clothes worn in the sick-room must be regarded as infectious, as undoubtedly they become so through contact with the patient, and the attendants should therefore, before mixing with others, have the opportunity of changing everything and thoroughly washing in some room apart from that occupied by the infectious person. The same precautions must be taken with regard to the food supplied, the articles used, and the linen soiled in the sick-room. The strictest cleanliness must be enjoined upon the attendants; let them never place their hands to their mouths or touch articles of food until after careful and thorough washing; let the dejecta be received into a bed-pan containing a suitable disinfectant, at once covered, and immediately removed and disposed of; let the bed-pan and the pan of the water-closet be thoroughly cleansed, and the latter efficiently flushed. The same care should extend to all articles which come in contact with the patient, and which should be kept for his use alone. Soiled linen must be at once removed and placed in a pail or tank containing disinfecting fluid, and subsequently boiled and washed apart from other linen.

The length of time the invalid is thus kept in quarantine can only be decided in each individual case, but in the table already given will be found the average length of time which is required for this purpose. With regard, however, to two diseases, scarlet fever and small-pox, quarantine should be maintained until the shedding of skin in the former disease and of all scabs in the latter, has ceased. At the conclusion of the illness great care should be taken to cleanse the body and hair with frequent baths. After the last bath, fresh clothes should be worn, which have not been brought into the sick-room during any part of the illness. Thus purified, the prisoner may be set at liberty, although, if it be possible, it would be well for another week or two to avoid close contact with those who are known to be susceptible to the disease.

The next step is to render innocuous the room which has been occupied — the bed, bedding, furniture and clothes which have been used by the infectious person, care being taken to include garments worn even some days before the illness.

But before concluding this branch of our subject, we would desire to urge the destruction by fire of all articles which are of no great value, so as to reduce to a minimum any risk which may occur from inefficient disinfection, since for all that is left we must entirely depend for safety upon those chemical processes the consideration of which we must leave to a later chapter.

We have as yet not touched upon what the householder may do to prevent the admission of disease by means of milk. Our knowledge of the circumstances under which milk becomes infected is too vague for us to rely with too much confidence upon such precautions as we are able to take to prevent its infection, but we shall only be following the dictates of common sense if we entirely prohibit the use as food for man of the milk of any cow which has recently calved, or of any animal which is not in perfect health. We must carefully guard the milk pail from pollution with water which is not altogether free from impurity, particularly from matter of excremental origin ; and further, from risk of infection by proximity to any person who is suffering or has recently suffered from any of the infectious diseases. But when we have done all this we cannot be sure that our milk supply is a safe one ; there is indeed but one way in which the milk consumer can hope to ensure this. It has been noticed during more than one epidemic due to an infected milk supply that those who boiled their milk before drinking it escaped disease, while those who drank it unboiled suffered. This was observed quite recently in the outbreak of enteric fever in St. Pancras to which reference has been made ; in one house lived two children, both of whom received milk from the same source, but the one was considered a more delicate child than the other, and it was thought well for this reason that it should not drink milk that had not been cooked. Of the two children the child drinking the boiled milk escaped disease, while the other passed through an attack of enteric fever. The habit of boiling milk before using it for food is one which is far more common on the Continent than in England, but it is a custom we should do well to adopt. We know that raw ham will under certain circumstances produce a fatal disease amongst those who eat it, a disease from which English people are no doubt preserved from their custom of always cooking it before consumption. If they could learn to recognise the wisdom of always cooking milk with the same regularity as they do meat, much of the disease conveyed by this means would be prevented.

By the means we have described we may hope very considerably to reduce the prevalence of certain diseases amongst us ; those which are dependent upon filth conditions, such as cholera and enteric fever, might be practically eliminated from our death returns ; scarlet fever and diphtheria would be lessened if we could, by care of our food supplies, cut off one of the channels by which they are conveyed. But there would be still many opportunities for these and other infectious diseases to be communicated, and we shall therefore be glad to learn some further means by which disease can be escaped.

CHAPTER IV.

MEANS OF PRODUCING INSUSCEPTIBILITY TO INFECTIOUS DISEASE.

THUS far our efforts have been directed to showing how we may escape exposure to infection, and it will be seen that we have been obliged to rely upon methods which are at the best not always infallible.

It was no wonder, then, that other methods than those we have described have been sought for, methods which aim less at avoiding infection than at rendering the body proof against its invasion.

If we cannot prevent the seed being air-borne into our meadow, may we not endeavour so to influence the soil that the seed may find no material upon which it can exist? We know that if the disease has been suffered once it is only rarely that it will find for itself food-material a second time in the same person.

It was with this knowledge that in the last century attention was directed to finding some way, different from that which nature provides, by which man could pass through a less fatal attack of an often fatal disease, and live protected against its influence afterwards. It was a century and a half ago that Lady Mary Wortley Montague introduced into England the custom of inoculation for small-pox.

When small-pox is contracted in the natural way, a period of twelve days elapses between the time of reception of the poison and the time when the first symptoms appear, and a period of fourteen days before a general eruption breaks out over the body. When small-pox is inoculated, the course of the disease is different. On the day after inoculation a small papule or elevation shows itself at the place where the puncture is made, and on the tenth or eleventh day a general rash breaks out over the body.

The course of the disease is, it will be seen, hastened when the virus is inoculated; and further, the affection is usually of a milder type than when contracted in the ordinary way. While this method had the advantage of reducing mortality, it was unsatisfactory for more reasons than one. In the first instance, it was attended by some loss of life, and secondly, whoever was inoculated was a source of danger to other susceptible people during his whole illness. But people in former days were but too glad to find any way of mitigating the severity of this dire disease, and this method was therefore practised until Jenner's great discovery, in 1798, led to the introduction of vaccination, and rendered inoculation unnecessary.

Jenner observed that the milkers of cows were not attacked with small-pox, a fact which attracted much attention at a time when to escape from small-pox was a comparatively rare event. He further observed that these people contracted an affection from the cow which could be communicated by inoculation from one individual to another, and that protection from small-pox was enjoyed by those who were thus inoculated. It has remained for future generations to understand more thoroughly how this protection is brought about. In the time of Jenner, cow-pox, the disease communicated from cow to man, was of much more constant occurrence in the cow than at the present time. Now it is a rare event for cow-pox to be found. What, then, has happened to prevent the appearance of this affection amongst these animals? To answer this question let us think for a moment of certain points in the behaviour of the disease; first, it occurs only in the female animal, that is, the animal with which man comes most in contact; secondly, the disease appeared on the teats and udder alone, the very parts of the animal constantly exposed to human touch. A moment's thought leads to the conclusion that man must in some way or other be the means of communication of cow-pox to the cow. But whence comes the disease which is thus conveyed?

Before the introduction of vaccination, it was, as we have said, the exception for any one to escape small-pox, just as in our time it is the exception for individuals to suffer from this disease; supposing, therefore, that man, while suffering from small-pox, in the act of milking inoculated the cow, his opportunity for doing so at the present time would be enormously reduced. Thus we can understand, that if cow-pox in the lower animal depends for its origin upon small-pox in man, it would necessarily be more seldom found in the present day. There is, indeed, but little doubt but that cow-pox results through the inoculation of the cow with the small-pox of man, and that the passage of the virus through the lower animal so modifies it that it can be again introduced into man, producing an affection sufficiently like small-pox to protect from an attack of this disease, without being attended by risk to life or by any power of communicating itself except by the process of inoculation.

The circumstances under which the cow can be thus inoculated with small-pox matter are not well understood, and the operation is very difficult of performance. Many have tried unsuccessfully again and again, others have succeeded by inoculation of the cow with small-pox matter in producing small elevations or papules which have again given rise to small-pox in man when the fluid they contain was introduced into his system. It is, however, very difficult in the laboratory to exactly imitate nature, seeing that we do not know what the conditions are under which the cow could contract this disease.

However much we may speculate on the question as to how such inoculation may be performed, there is no doubt that it has been accomplished by a few individuals, and the success of the few is of infinitely more importance so far as proof is concerned, than the failure of the many. As a result of what is known of cow-pox in the cow, we have but little hesitation in accepting as probable in a high degree that vaccine lymph is really small-pox modified by being passed through the cow.

Vaccination, indeed, resembles inoculated small-pox with three important exceptions ; *the general eruption of small-pox does not occur, the affection is not communicable from person to person except by inoculation, and does not endanger life.*

We thus come to see how vaccination or small-pox modified by transmission through the cow, is capable of protecting against small-pox. As yet the same method of protection is not available for the other infectious diseases to which we are liable, but for some animals, more fortunate than man in this respect, a similar discovery has been made. Every one has read of the terrible destruction of sheep and oxen abroad by the disease which is known as anthrax, an affection which is communicated from animal to animal with but too much readiness, leading to the growth of an organism in the blood and internal organs, which in a very few days causes the death of the creature. So fatal has this disease been that many efforts have been made to arrest its course, and at last M. Pasteur has succeeded in growing outside the body the poison which causes the affection, and has, by cultivating it in an appropriate fluid, produced an organism which, when inoculated into sheep, causes an affection which does not as a rule end fatally, but which protects the animal against subsequent attacks of the same disease.

In 1883 there was an outbreak of disease among cattle in the Argentine Republic so destructive that Dr. Roy, of the Brown Institution, was sent to investigate its nature. Finding this disease to be anthrax, Dr. Roy proceeded to seek a means of protecting the herds against this destructive malady. He was fortunate in discovering that the prairie dog, a rodent, could itself be inoculated with anthrax, and that if the spleen were taken from such an animal which had died from this disease, and the virus which it contained used for the inoculation of cattle, a mild and non-fatal attack of anthrax resulted, which protected them against subsequent attack. Thus the passage of the virulent anthrax poison through the body of a rodent so altered its character that it could be used for the inoculation of cattle just in the same way as the passage of virulent small-pox poison through the cow so alters its character that it can with safety be used for the inoculation, *i.e.*, the vaccination, of man.

This then is the method which has already since Jenner's time been the means of saving many millions of lives from small-pox, and which might save many more were the value of the operation and the proper mode of its performance, better understood.

At the present moment, while continued efforts are being made to mislead the public as to the value of vaccination, it will not be out of place if we consider very briefly how much vaccination has done for us, and how much it might do if its value were more generally recognized. First, let us point out that small-pox is not one of those diseases which are known to be spread through the excreta, or through milk ; we cannot therefore hope by improved methods of drainage, or by care for the protection of our milk supply, to lessen this disease among us. Just as we are liable to contract measles and whooping-cough whenever we may become exposed to its infection, so we are *naturally* equally liable to suffer from small-pox. There are probably not very many people who attain adult life without having passed through measles, so before vaccination was introduced there were not many people who in early life escaped small-pox. Wherever we turn the records of past times tell the same story. In the tenth century, Rhazes, a Persian physician, begins a book by inquiring "Why do we seldom find one or two people out of twenty who have not suffered from small-pox ?" In the last century, Süszmilch, who was working at statistics concerning population, stated that a twelfth of the total deaths were due to small-pox. And again, Dr. Storch, who died at Eisenach in 1751, says that "from love or small-pox few people were exempt." The behaviour of small-pox in the last century in our own country is especially instructive. Dr. J. C. McVail, of Kilmarnock, has recently shown what small-pox did in that town. In the beginning of the year 1728 the schoolmaster of Kilmarnock began to keep a register of mortality for his parish, from which Dr. McVail has elicited the following information. First, that death from small-pox was much limited to children under five years of age, and almost entirely to children under ten years of age. Every four years came an epidemic attacking nearly all the susceptible people in the district, killing many and protecting the majority of the remainder against subsequent attack. The chances of any susceptible person escaping two epidemics was so remote that not half a dozen deaths occurred after ten years of age. All that could die, died before this age. But of those below five years of age, how many died? Of every 1000 born, 116 were killed by small-pox before attaining this period of life. So regular were the epidemics in making their appearance, and so fatal the disease that Dr. McVail, writing of Kilmarnock in that time, says that "as regards small-pox there were in fact three Kilmarnocks. One, a Kilmarnock of 3700 persons, had no fear of its attacks. These had already met with and battled with the disease-fiend. On many were to be seen the marks of the conflict. Some were blind, some had lost their hearing, many were permanently injured in constitution, and very many were scarred and disfigured for life; and for every one that had conquered another had fallen never to rise again. There was indeed a second Kilmarnock under the green sod of the kirk-yard. The Kilmarnock which had reason to dread the epidemic's approach was the Kilmarnock least able to meet it. It consisted of a little band of children, numbering less than five hundred in all. Every such group that came into existence had to face, within four or five years of birth, the most terrible physical enemy that it would ever meet, and having fought the battle, some were added to the maimed and distorted who formed so large a portion of the population, and others were laid beside those who had been destroyed by former epidemics."

Small-pox, then, behaved in Kilmarnock much as measles does amongst us now, except that while measles comparatively rarely kills, small-pox killed or disfigured a large proportion of its victims. But the story of Kilmarnock is doubtless true for other towns as well. In an old record of the town of Chester, in the possession of Professor Paget, of Cambridge, we find that in the year 1774, of a population of 14,713 persons, 546 died from disease, of whom 202 lost their lives from "natural small-pox"; and again, it should be noted that the 202 deaths were entirely confined to children under ten years of age, and all but twenty-two to children under five years. A survey or census of the town of Chester in that year, showed that of the 14,713 inhabitants but 1060 had never had the small-pox, or 1 in 14; the old record stating that "one-eighth part of mankind die of the natural small-pox."

How different from the behaviour of small-pox in our time, when it is the exception and not the rule to have this disease, when scarred faces are comparatively seldom seen, and when instead of *an eighth*, not *one-hundredth* of mankind die from its effects. It is not, however, by all people equally that this reduction of liability to death from small-pox is enjoyed. An examination into the comparative small-pox death rates among vaccinated and unvaccinated persons shows this conclusively. For this we may refer to the memorandum of Dr. Buchanan, medical officer of the Local Government Board, on small-pox in London, in the year ending May 29, 1881, and which can be best understood from the following Table, which we extract from the Parliamentary return:—

Comparative Small-pox Death-rates among Londoners, Vaccinated and Unvaccinated respectively, for the Fifty-two Weeks ended May 29, 1881:—

Death-Rate of People of subjoined Ages.	Per Million of each Age of the Vaccinated Class.	Per Million of each Age of the Unvaccinated Class.
All ages	90	3,350
Under 20 years . . .	61	4,520
Under 5 years . . .	40½	5,950

Or again, let us learn from the same source the conclusions which are drawn from an analysis of the deaths from small-pox occurring during 1881 in London amongst children under ten years of age. In this year among 55,000 children in London who had not been vaccinated, there were 782 deaths from small-pox; among the 861,000 children who had been vaccinated there were 125 deaths from small-pox. "If the London children under ten who were unvaccinated had had the protection which the current vaccination gives, not 782 of them, but at the outside *nine* would have died of small-pox during the year. If the 861,000 vaccinated children had died at the rate of the 55,000 unvaccinated, we should not now be considering 125 small-pox deaths, and how they can be reduced, but we should be confronted with an additional 12,000 and more deaths from small-pox, occurring during the year in the London population under ten years of age." *

A further proof of the value of vaccination as a means of protection against small-pox is to be found in the immunity enjoyed by attendants in the Small-pox Hospitals upon persons suffering from small-pox. At the London Small-pox Hospital at Highgate, where many thousands of people were treated, small-pox among the attendants was practically unknown, the only case in forty-eight years occurring in a man who refused to be revaccinated, and the same story is true of other institutions.

Dr. Collie says, "During the epidemic of 1871, 110 persons were engaged in the Homerton Fever Hospital in attendance upon the small-pox sick; all these, with two exceptions, were revaccinated, all but these exceptions escaped small-pox. The experience of the epidemic of 1876–77 was of the same kind; all revaccinated attendants having escaped, while the only one who had not been vaccinated took the disease and died of it. So in the epidemic of 1881, of ninety nurses and other attendants of the Atlas Hospital Ship (Small-pox), the only person who contracted small-pox was a housemaid who had not been

* Eleventh Annual Report of the Medical Officer to the Local Government Board, 1881–82.

revaccinated." If these people had all previously had small-pox, their escape would have been no matter for surprise; but in view of the fact that they had not so suffered, and that those who had not been revaccinated contracted small-pox, there is not the least doubt that the immunity of the remainder was the result of vaccination.

There is still another lesson to be learnt than that of the saving of life. It is that whereas in the last century death from small-pox was almost limited to early life, now it is the older persons who more particularly become its victims. How has this change been brought about? The story of Kilmarnock and the story of Chester make this perfectly clear. In the last century but few people, as already stated, attained adult life who had not in their early days passed through an attack of small-pox; now but comparatively few have thus suffered, or rather they have suffered in early infancy from that affection which we know as vaccination, but which there is so much reason for believing is small-pox modified by transmission through the cow.

Now future protection against disease is dependent upon the thoroughness with which the susceptibility of the individual is exhausted, and it is more than probable that vaccination in one or two places only does not protect for so long a time as small-pox does when contracted in the natural way.

We must then learn the following lesson: *The value of vaccination as a protection against small-pox depends upon the manner in which the vaccination is performed.*

It is possible by the introduction of vaccine lymph in one small place, to obtain complete protection against small-pox; but for a while only. If the protection is to last for a number of years, the vaccination should be in five, or in four places at the very least, and should be performed in such a manner, that the scars resulting should together have an area of at least one-half of a square inch.

Moreover, the amount of protection is dependent upon the vaccination running a natural course. The fact that quantity and quality of vaccination are alike concerned in the matter of protection is undoubted, not only as affecting the prevention of disease, but, further, if the vaccinated person subsequently contracts small-pox, his chances of death or recovery depend upon both these conditions. The latter is well shown by the following Table, compiled by Dr. McCombie, of the Deptford Small-pox Hospital :—

Number and quality of vaccination marks.		Mortality in each 100 attacked with Small-pox.
One mark	Good	6·4
	Indifferent	16·7
Two marks	Good	3·7
	Indifferent	11·2
Three marks	Good	3·7
	Indifferent	7·4
Four marks	Good	2·7
	Indifferent	4·8

Or we may accept Dr. Collie's summing-up of the rates of mortality amongst persons suffering from small-pox, by saying that "the unvaccinated will die at the rate of about 50 per cent., the badly vaccinated at the rate of about 26 per cent., and the well-vaccinated at the rate of about 2·3 per cent." *

Upon properly performed vaccination we must, therefore, rely for protection against small-pox, and as we have said, that to be properly performed, the lymph should be inserted so as to produce at least four or five vesicles, and should be of a quality to produce vesicles which will run a natural course.

Wherever it is possible, and it is always possible in towns, vaccination should always be done *direct* from one child's arm to another, or from the calf to child, both being in the room at the same time. If lymph stored in tubes, or on ivory points be used, it is more likely to produce fewer and smaller vesicles than intended, and the individual may thus be insufficiently protected against small-pox. Nor can this misfortune be readily remedied, for, as already stated, the production of one vesicle will

* Quain's 'Dictionary of Medicine.'

render the individual altogether insusceptible for a time and nothing can be done until he again becomes susceptible to this affection. In all probability his susceptibility to attack from natural small-pox returns at the same time, and it is usually a mere chance as to whether he is again vaccinated before being exposed to infection.

If vaccination is performed in the best way in infancy, may we assume that we are proof against attack from small-pox for life? Experience has shown that we may not do so, for although vaccination in infancy will in most cases lessen the severity of small-pox during the whole period of existence, and thus largely save life, its full protection against attack from small-pox has a tendency gradually to diminish as time progresses, and every person should, therefore, on attaining the age of puberty be revaccinated, care being taken that when possible the vaccination is done direct from the child's arm or from the calf, and as thoroughly as in primary vaccination. As a general rule, this will be sufficiently early; but if the primary vaccination be badly performed, or if there be known exposure to infection, this period of life must not be waited for.

With properly performed vaccination and revaccination, small-pox would be practically abolished from the country. That revaccinated persons are protected against small-pox there is the strongest evidence—witness the protection of the nurses in the hospital already referred to.

In practice it will be sufficient if all persons are properly vaccinated in infancy and revaccinated at puberty. The number of cases of small-pox which occur after efficient revaccination is so infinitesimally small as not to be worth consideration.

We have already shown that inoculated small-pox runs a different course from small-pox acquired in the natural way, and that the eruption appears some days earlier; so we find that vaccination, which we have regarded as representing the local vesicle without the general eruption, runs a course resembling that of inoculated small-pox. This difference in time becomes of great importance when it is desired to protect from disease those susceptible persons who may have already been exposed to infection. It is quite possible even after infection by small-pox, that such a person may still be protected by vaccination.

Vaccination, we have said, passes more rapidly through its various stages than does natural small-pox, and can, therefore, overtake the latter. Vaccination becomes protective when around the vesicle an areola, or ring of redness, has appeared, and this is to be found on the *ninth* day after the performance of the operation. In small-pox, *twelve* days elapse between exposure to infection and the development of the first symptoms, hence, vaccination gains three days upon small-pox, and if performed within the first three days of exposure to infection of small-pox, the latter disease will be prevented. For the knowledge of this fact we are indebted to the late Mr. Marson, who says, "Supposing an unvaccinated person to inhale the germ of variola (small-pox) on a Monday; if he be vaccinated as late as the following Wednesday, the vaccination will be in time to prevent small-pox being developed; if it be put off until Thursday, small-pox will appear, but will be modified; if the vaccination be delayed until Friday, it will be of no use, it will not have had time to reach the stage of areola, the index of safety, before the illness of small-pox begins." *

Something then is to be done even at the last moment; but it is obvious that no wise person would wait until he had been exposed to infection before seeking so simple a means of preserving his life and health.

Nor are there any risks attending the operation which need be taken into account for any other reason than to ensure its proper performance. The inoculation of another disease cannot take place where proper care is exercised in the selection of lymph and in the mode of performance of the operation. The occurrence of erysipelas is the rarest event; with proper care during the vaccination

* Marson, art. "Small-pox," in Reynolds' 'System of Medicine.'

and afterwards, it need not be feared. There is, indeed, but one real risk in connection with vaccination, and one which should be especially borne in mind at the present time, viz., that in forgetting the terrors of natural small-pox, people may eventually cease to take this simple precaution for its prevention, and may only learn to appreciate the value of the remedy after a dearly bought experience.

CHAPTER V.

DISINFECTION.

If it could be ascertained whether the use of so-called disinfectants had done more harm or more good, it is probable that the balance would be found in favour of the former view. There is too much readiness to believe that the placing of one or another of these substances in a saucer in a sick-room, or that the sprinkling of another over infected garments, has an influence in preventing disease which may permit the use of the disinfectant to replace precautions of an important character. Thus the writer has frequently found that the separation of the sick from the healthy has not been regarded as necessary when a so-called disinfectant can be used, and that the sprinkling of the floor or the spraying of the air has been allowed to replace the most ordinary requirements of cleanliness.

While, however, it is easy to condemn methods which we know to be futile, it is not less difficult to point out any one method which can be regarded as conclusively satisfactory. There are few subjects on which we have less information than the means of destroying infection, and our ignorance is dependent upon the difficulties which stand in the way of testing the value of the various substances which may be useful for this purpose.

If it were possible to separate the poisons of the different infectious diseases, act upon them with some of these substances, and then introduce them into the bodies of susceptible people, we should soon be able to form a more distinct idea of the value of the disinfectant. This is in practice impossible, for apart from other reasons, there are but very few of the infectious diseases whose virus we could thus deal with. Nature herself performs experiments but of too uncertain a character for us to draw any definite conclusions from them. If any person after exposure to a presumably disinfected garment should develop fever, and other possibilities of infection could be excluded, we might assume that the garment is responsible for the disease, and that the disinfection was worthless; but the difficulty remains that the method of performing the disinfection may be at fault, not that the disinfectant is itself to blame.

On the other hand, if the garment failed to infect, we could not assume that the disinfection was complete, seeing that we could not be sure in the first instance that the poison was introduced into the system, or that the person receiving it was susceptible to its influence.

It is therefore necessary that we should rely only upon definite experiment for the purpose of ascertaining which are the best disinfectants, and the best method of using them; such experiments have been performed by Dr. Buchanan Baxter in England, and by Drs. Koch, Wolfhügel, Gaffky, Löffler, Fischer, and Proskauer, in Germany. The materials used were anthrax virus, vaccine lymph, septic poison, fungi, &c., for it was thought, and no doubt correctly, that the organisms which were the cause of the different infectious diseases were likely to be affected in the same manner as those chosen for experiment.

Disinfection to be of service must be capable of destroying the whole of these organisms wherever they may be situated, as well as their spores, which are more tenacious of life.

The same disinfectant is not always selected under all circumstances; thus, that which is required for the purification of the air of an infected room is different from that upon which we must rely for the disinfection of clothes, or of bedding, or of the excreta. It is sometimes sufficient to render the virus temporarily inoperative, and the same disinfectant would not be employed for this purpose as for its destruction. It will therefore be well if we consider each of these conditions separately, and learn how we may best proceed to render innocuous the room occupied by, the clothes worn by, the bedding used by, and the discharges of, the infectious person.

First, we have to purify from infection the air, walls, ceiling, and floor of the room, as well as the furniture it contains; for this purpose sulphurous acid gas, which is produced by burning sulphur or bi-sulphide of carbon, has been most largely used, and is perhaps of some value. Recent experiments have, however, shown that where the organisms lie in a thick layer, or in any way not immediately on the surface, they are liable to escape from destruction; and again, if they are in the condition of spores they do not seem to be affected by this gas; thus the spores of anthrax were found by Dr. Koch to be unaffected after exposure to the gas for 96 hours, and subsequently, when inoculated into a mouse, speedily proved fatal.

The only reagents which may be really trusted for the fumigation of rooms are bromine, chlorine, and iodine; of these the first two are the most reliable. Drs. Fischer and Proskauer, experimenting with these reagents, found that to ensure success it was very necessary that the atmosphere of the room should be thoroughly moistened, and that a certain strength of the gases was essential; the greater the moisture within certain limits, the smaller the quantity of gas needed. Neither of these gases have any power of penetration, and may, therefore, only be trusted to disinfect surfaces. Bromine has certain disadvantages connected with its use, in being more destructive and more costly than chlorine, and it will be well, therefore, to rely upon the latter.

To begin with, the room should have its floor, doors and woodwork generally moistened with water, the fireplace and windows should be closed to prevent the escape of the fumes, and basins containing the disinfectant should be placed at different levels about the room, so as to ensure its even distribution. Each basin should contain chloride of lime into which a bottle containing hydrochloric (muriatic) acid should be so placed that its contents will gradually trickle out into the chloride of lime. The room should then be rapidly vacated, for the fumes will become unbearable, and the door closed. Twenty-four hours should elapse before the door is again opened, the room should then be well ventilated and thoroughly cleaned ; the paper should be stripped, the ceiling limewhited. The amount of disinfectant used must, of course, be in proportion to the size of the room. Drs. Fischer and Proskauer found that there must be six ounces of chloride of lime and ten ounces of hydrochloric acid for each cubic yard the room contains, which is roughly at a cost of nearly twopence a cubic yard.

Before leaving the subject of disinfection of rooms it will be well to point out the utter futility of attempting their disinfection, during occupation by the sick, by the use of other substances which are now so freely placed about rooms in saucers, and which for such a purpose are practically as valueless as the charms and philtres to which we have referred in our earlier pages.

For the disinfection of different articles we must trust to other reagents ; and here again we must remember that the most recent knowledge has shown how little dependence can be placed upon the majority of substances which are now used. In the hands of Koch, the use of corrosive sublimate has been most successful. Experimenting with living organisms, he found that a solution of the strength of one part in five thousand was sufficient to destroy most organisms, while one part in a thousand * destroyed all. The solution had but to be painted over the surface of the infected article and allowed to remain there for half an hour to do all that was necessary ; it could then be washed away and the article thoroughly cleansed. There is, however, one serious drawback to its use—its exceedingly poisonous properties ; as small an amount as three grains has been known to kill a child, and but a little more is sufficient to cause the death of a man or woman. It is very inexpensive, and its poisonous properties are the only objection to its use, but the risk may be diminished

* Roughly one ounce of sublimate dissolved in six gallons of water.

by colouring the solution and adding some strong smelling substance, and keeping it (preferably in a concentrated solution) under lock and key, only placing it in the hands of others after dilution, and at the time of use. In face of this difficulty it is satisfactory to know that heat is an effectual means of destroying all organisms, and that most articles of clothing or of bedding can be exposed to the requisite temperature without injury. In a previous chapter we have referred to outbreaks of disease by infected milk, and have commented on the immunity enjoyed by those who only drank the milk after it had been boiled. We shall, therefore, not be surprised to find that the experiments of Drs. Koch, Gaffky, and Löffler on anthrax virus teach the same lesson, and show that even the spores are killed after two minutes' exposure to boiling. Now all small articles of clothing and linen both from the body and the bed, can be boiled, and there is therefore every reason for systematically carrying out so simple a process.

It is not so easy a matter to raise to a sufficient temperature the whole of a pillow, bed, or mattress, when exposed to a dry heat as, for instance, in an oven; it will take a number of hours before the heat penetrates the interior so as to raise a thermometer placed there to a temperature sufficient to destroy organisms. It would, therefore, not be wise to trust for the purposes of disinfection to such baking as may be done in an ordinary kitchen oven. The above experimenters found that a temperature of 140° Centigrade (284° Fahrenheit) for three hours was required to destroy the spores of anthrax, when dry heat was employed.

Fortunately, by means of "superheated steam," heat may be otherwise applied to those articles which cannot be boiled; this, however, cannot be done at home, for it requires a special apparatus. While by this method a temperature of not less than 100° Centigrade (212° Fahrenheit) is needed to destroy the spores of anthrax, a far less temperature than 140° will answer every purpose. Experiment has, indeed, shown that 105° is the maximum required.

For the penetration of a bed a period of three hours is sufficient, and may be trusted to for the disinfection of any ordinary bed or bedding. When the article to be disinfected is of great thickness or of dense substance an interrupted application of the heat is useful in assisting the penetration of the steam. By this method the article to be disinfected exchanges the cold air it contains for the hot steam to which it is exposed, and the maximum heat in the interior is more rapidly attained. Steam has the further advantage of not damaging the articles disinfected to the same extent as hot air. Cotton and wool fibre stand exposure to it well, and feathers and horse-hair are not injured. Colours fade somewhat, becoming a lighter shade; leather only will not stand exposure to steam.

We have still to decide upon what is to be done in the sick room with infected linen and with the infectious excreta of the patient. Linen, we have seen, may be freed from infection by thorough boiling, but arrangements will have to be made for its safe disposal during the period that it awaits boiling, and this we would recommend should be as short a time as possible. It may during this interval be steeped in a solution of corrosive sublimate of the strength of one part in a thousand; if this fluid be objected to on account of its poisonous properties, it then becomes necessary to use some other re-agent, and this will necessitate our falling back upon one of a somewhat numerous class which, while they do not destroy permanent spores, are yet very useful in preventing their further development while in contact with the disinfectant. This class includes, amongst others, carbolic acid and thymol; to the first of these objection may be taken that its use in place of a solution of corrosive sublimate is merely substituting one poison for another; it is, however, in such general use that its poisonous qualities are universally recognised, and owing to its powerful odour the probability of accident occurring from its use is more limited. A solution of the strength of two parts in a hundred is sufficient to prevent the further development of organisms, but it will not, as has already been stated, destroy the spores of all the poisons by which its value can be tested; in this proportion it is not destructive of linen. The second, thymol, is much more free from objection on the score of poisonous qualities than carbolic acid, and appears to answer as well in preventing further development of the spores. It may be used in a much more diluted form, one part in eighty thousand, in the hands of Koch, being found sufficient.

Either carbolic acid or thymol may be employed for moistening the sheet which it has been recommended should hang over the door of the sick room to prevent the egress of air, and may be placed in the bed-pans which receive the excreta of the patient; the flushing of water-closets and drains may also be performed with the same fluids.

But while we devote our attention to the destruction, and prevention of development, of infectious organisms, given off by the sick, we must above all things be careful to attend to the ordinary requirements of cleanliness, for we cannot assume that all emanations thus produced will come within the reach of our disinfectants. At the same time we must remember that the dilution of the infectious poison by air is a means of reducing its potency, and the sick room should therefore be freely ventilated, in the interests both of the sufferer and his attendants.

Again, both during and at the conclusion of his illness we should avail ourselves of natural disinfection; and by this we mean the action of sun and air. The exposure of bed and bedding to these influences appears to have some value, which makes us unwilling to omit mention of them here; they should not, however, be allowed to supersede the artificial disinfection which we believe to be necessary for the complete destruction of the infective poisons; but the probability that nature herself, though perhaps more slowly, accomplishes the same end by these means, makes us desire to utilize them to the utmost.

A room that has been disinfected should remain unoccupied for some days, and the windows should be left constantly open, both day and night, to allow of the free action of the elements.

It will be convenient here to make some reference to the precautions which should be taken in the event of death from any of the infectious diseases.

In the preparation of the body for the grave, it should be recollected that it is still capable of infecting those who may come in close contact with it, and the same care must be exercised by those whose duty it is to perform for it the final offices. It should be washed with fluid containing one of the disinfectants mentioned above, and as soon as possible placed within the coffin, which should be at once closed. The removal of the body to another room should not be encouraged, seeing that such removal prevents the limitation of contagion to those parts of the house already infected. Burial should not be delayed ; our thought must be for the living, and nothing but an unwise sentiment can make us wish to retain above the earth that which may be a further cause of death.

CHAPTER VI.

GENERAL PRECAUTIONS.

So far we have devoted the space at our disposal to giving some account of the manner in which infectious diseases are caused and communicated, and of the means which are at the disposal of every individual to prevent the occurrence of such disease, and to limit its extension should it make its appearance in any dwelling.

In conclusion, let us dwell very briefly upon the precautions which we must take as communities with the same object. If any person suffer from one of the infectious diseases, his illness does not affect himself alone, but is a matter which concerns the community in which he lives. It concerns them in two ways; first, that the sufferer may be a source of danger to those about him, secondly, that the cause of his disease may be a cause of the same disease to other persons.

It is the duty of every person so suffering to submit to certain restrictions which must be placed upon him on behalf of the safety of other people. During the time that he is infectious he must not allow himself to associate with any but those who are required to minister to his wants, and he must thus remain in durance until he is informed by a competent authority that he is no longer a source of danger. There are many people who will willingly take these precautions, indeed, all right-minded persons would not hesitate to do so; there are others, again, less thoughtful, who will not subject their own convenience to the safety of others. It thus becomes necessary, in the interest of the community, that each case of disease should be made known to the official whose duty it is to protect the health of the number.

Such knowledge would not only serve to check the carelessness of those who are ignorant of the harm they are doing, but would often enable the cause of disease to be discovered. Without such information, an infected water or an infected milk-supply may be carrying disease and death into many a home, and the existence of the outbreak so caused remain unknown until the poison has spent its force. If each case were at once made known, a careful officer would at once suspect from an increase in the number of cases that some new cause was in operation, and would ascertain whether the drinkers of a particular water, or of milk from a particular dairy, were suffering out of proportion to other persons, and thus a number of lives would come to be saved through the stoppage of the supply.

Every person should assist, both in his own interest and that of those among whom he dwells, in having every case of infectious disease properly investigated. Only by such means can its prevention seriously be undertaken.

Every community should insist upon the proper removal and disposal of all waste matter, whether excrementitious or of other kind, and pollution of the earth should be rendered impossible.

A sufficient and wholesome water supply should be provided, one which, under no circumstances, is liable to contamination.

While attention is devoted to water supply, other food supplies should not be forgotten. Dairy farms should be under constant medical supervision, to prevent outbreaks of infectious disease, and to ensure that the water which is used for feeding the cows or for washing the pails, is free from contamination. No milk should be taken from any but healthy cows, and this provision should exclude cows which have recently calved. No person engaged in attendance upon the cows, or in carrying the milk, should be permitted to continue his duties if he have any infectious disease himself, or if any person living in the same house with him, or with whom he be otherwise in contact, is suffering from such affection. Milk should be stored only in those places where it is not exposed to contamination. It is known readily to absorb any matter which escapes into the air in its vicinity, and it should therefore be stored only in places specially prepared for its reception, which are kept scrupulously clean, and do not contain an inlet to any drain.

In the event of suspicion attaching to a milk supply, each milk-vendor should be prepared to supply all information as to his customers, and should so arrange his books that, should he draw his supplies from more than one farm, it would be possible at once to tell whether the drinkers of milk from one or another source were the sufferers.

The centres of communication between numbers of individuals should be carefully and constantly watched, every outbreak of disease should be subject to investigation, and if it be found that those who congregate at any one of these centres, are suffering more than others, inquiry should be made in this direction.

If it be found that the children of a particular school are specially attacked, it should be ascertained how far the school is itself exercising a prejudicial influence. Such information can only be obtained when it is known for a number of families, whether the first person attacked was the child attending a school, regard being, of course, had to his opportunities for infection elsewhere, and to the susceptibility to disease of other members of each family.

Generally speaking, no child who is not himself free from dangerous infectious disease, or living in the same house with a case of infectious disease, should be permitted to attend school where a number of other susceptible children are. Usually it is sufficient to exclude from school, children who are themselves a source of danger; there are times, however, when the closure of the school becomes necessary in the interests of the health of the community. Such interference with education should not be permitted without much consideration and without strong proof that the continuance of the school is a cause of disease; thus it should be ascertained whether other opportunities for infection exist which would continue or be increased if the school were closed, such, for instance, as children congregating together at play. And again, if it be found necessary to close a school, it should be learnt whether it would not be sufficient to close that part which would exclude from attendance only those of a particular age. It may, for instance, have happened that the same disease may have been prevalent in the neighbourhood but a few years before, and that only children born since that time are now susceptible to the malady.

The influence of laundries should always be watched. No person suffering from infectious disease should be allowed to remain in a house where linen from other houses is received for washing, and no householder should allow infected garments to be sent for washing to any place before careful disinfection, and unless it can be washed apart from those of other persons. The writer has known one instance in which small-pox was contracted by a laundry-man and became a source of disease to another family through infection of the linen.

But while precautions are taken unceasingly in the directions we have indicated, it must not be assumed that the maximum good has been accomplished. As our knowledge of infectious disease increases, so will our opportunities for its prevention grow likewise. We must then be prepared to accept the teachings which time alone can give, and apply the experience of the past to the prevention in the future of those diseases which may then attack mankind.

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