**On the poisons of the spreading diseases : their nature and mode of distribution : a lecture, delivered before the Congress on the Sewage Question, held at Leamington, on Tuesday, Oct. 25th, 1866 / by Benjamin W. Richardson.**

# ON THE POISONS OF THE SPREADING DISEASES:

## THEIR NATURE AND MODE OF DISTRIBUTION.


## A LECTURE,

DELIVERED BEFORE THE

## CONGRESS ON THE SEWAGE QUESTION,

HELD AT LEAMINGTON, ON TUESDAY, OCT. 25TH, 1866.

BY

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LONDON:

JOHN CHURCHILL AND SONS, NEW BURLINGTON STREET.

1867.

# PREFACE.

PREPARED on very short notice, delivered from brief notes, and printed from a short-hand report, this Lecture, though most accurately taken down by the reporter to the Congress, Mr. Hill, lacks I am aware many of the characteristics of system and expression which should mark an essay written at leisure, and in the quiet of the study. But as the Lecture is published at the request of those who heard it, and as their judgment was specially and unanimously in its favour, I cannot but hope, that, with all its faults, it may prove acceptable to that larger public to which it is now submitted.

B. W. R.

LONDON, 12, HINDE STREET, W.

February 10th, 1857.

# LECTURE

## "ON THE POISONS OF THE SPREADING DISEASES; THEIR NATURE, AND MODE OF DISTRIBUTION."

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MR. PRESIDENT AND GENTLEMEN:—When the energetic and earnest Secretary of this Congress, my friend Mr. Hitchman, stated that he should like me to deliver a lecture on this very interesting and novel occasion, I asked myself, with what subject can I come before such a Congress—a Congress, not essentially of medical men, not essentially of engineers, not essentially of sanitarians in the broadest sense, but a mixed Congress, at which, perhaps, ladies might be present, as well as gentlemen? I determined, at last, to take as a subject those poisons which produce the epidemic diseases. I made this selection, because the subject, in the first place, was very familiar to myself, and in the next place, because I believe,—and I think before I conclude this lecture you will agree with me,—that the great question of the disposition of sewage throughout this land can never be properly and practically understood, until each person who considers the subject knows the health-side of the question so far, as to understand with what he is dealing, when he is endeavouring, by means of an improved sewage system, to prevent disease.

There are several reasons why a lecturer should feel a difficulty in approaching a subject. I have often felt a difficulty in dealing with a hackneyed subject, when I have attempted to throw, what may be called, "novelty" into it; but, on this occasion, I feel a difficulty on the opposite side; I feel a difficulty in the novelty of the subject—for, in truth, this is one of the first lectures that ever been delivered

on this particular subject, and you constitute the first general audience that has listened to a lecture of this kind. I do not know, therefore, how I shall so approach the work as to make what must, necessarily, in some instances, seem abstruse, clear to your minds. I know that, on all points, I am not absolutely clear myself. I only see and feel that I have gone, perhaps somewhat, but a very little further than the mass of my scientific brethren in investigating this subject; and all I can promise is, that I will endeavour, to the best of my ability, to make everything perfectly clear from the beginning to the end, if you will be so kind as to lend me your indulgence.

### THE LAW OF LIFE AND DEATH IN NATURE.

In the first instance, let me dwell on this great law of nature,—that by the strict natural ordinance, a man should know no more of his death than of his birth. That is the first thing for us to fix in our minds. That is to say, according to the general rule which nature has laid down, subject to certain exceptions, inflicted by herself—for nature has exceptions to general rules—a man should be born knowing nothing of his birth, should go through a certain cycle of vitality, should sink into that "second childishness," or mere oblivion, of which our great poet tells us, and should ultimately die, knowing nothing of the fact of death. This may be called, in some senses, an Utopian idea, and may suggest the notion of a physical millennium. It is, however, strictly true that such is the law, and I believe the day will come when it will be so faithfully carried out, that men will actually, in the large number of cases, live to an extreme old age, and die in that second childhood of which I have spoken.

### CAUSES OF DISEASE EXTERNAL.

Meanwhile, we are surrounded by circumstances which lead to

disease; but when we begin to analyse disease, we find that every cause of disease with which we can in any way be conversant, is external to ourselves. We shall, perhaps, wonder at this, and say "What of hereditary diseases—of those diseases which pass from the parent to the child? Are they from an external cause? They are unquestionably. They were from an external cause in the first instance; and the impress established has been reproduced through a series of physical developments, until, at last, the disease for a time becomes, as it were, of permanence in a given family; but even in this case the primitive cause was outside the organism.

These external causes produce 214 diseases; and those are the whole of the diseases of the human family: that is to say, when we classify the symptoms together, so as to make them into great groups to which we can give specific names, we reckon up 214 diseases. The 214 diseases depend exclusively upon external causes, and these causes are only *six* in number.

The first of these external causes in the production of classes of diseases—the first, and the most natural—the one which came first, and will remain last, is *Atmospherical variation.* Such variation may be in regard to heat, or in regard to electricity. The second cause is *Error in diet*—from which there is a great group of diseases. The third cause is *Physical accident,*—such as lightning-stroke, falls, blows, or any physical influence which is thoroughly and directly appreciable. The fourth cause is *Habit, including occupation.* The fifth is *Parasitic migration;* and the sixth is *Organic poisoning.*

The first class of causes, Atmospherical variation, I must pass over. It gives rise to a natural class of diseases, such as inflammation of the lungs, croup, cold, and all affections which spring from mere atmospheric change. Errors of diet produce such diseases as gout, dyspepsia, and various kindred affections. Physical accidents I may leave without

a word. Habits and occupation affect much, but those we may dismiss from our consideration as unconnected with our present subject. There will remain then only the parasites and organic poisons, and these, as causes of disease, are immediately connected with sewage.

## PARASITES.

I shall not dwell long upon the subject of parasites. There are diseases which spring from parasites, and may be transmissible, as we have learnt from the labors of Küchenmeister, and Von Siebold, in Germany, and specially from our own most distinguished Helminthologist, Dr. Spencer Cobbold, who was the first to show that such transmission could occur through sewage matter. We know, for instance, to take one illustration, that the tape-worm is a parasite which affects the human subject, and may be derived from a similar parasite, in fact the head of one of its own kind. One animal becomes affected through another; the dog may pass the head of the tape-worm, and that head if it be taken up by sheep or swine, feeding on the grass or on other food, they may become affected with parasitic disease differing only in form not in essence. Thus also these parasitic diseases may be passed on from the animal that is *not* edible to the animal that *is* edible, and then again to man. Dr. Cobbold is of opinion, with regard to sewage, that it may be the means of carrying from human subjects these parasitic forms, and as these will naturally pass from the sewage to the land, then to the grass, so the disease will be transmitted from man to animals, and from animals to man, in a perpetual circle. It must be a rare occurrence connected with any form of sewage for this result to be produced, but Dr. Cobbold has given evidences and arguments which bear out the theory exceedingly well. We have not, however, yet tried experiments with sewage on a

sufficiently large scale to determine whether this liability should prevent us from using it on land either by irrigation, or as solid matter.

### THE ORGANIC POISONS.

The most important group, however, of disease—relating to our present work—is the group depending upon the action of those agents which I have called the organic poisons. These organic poisons are important to us on this special occasion because they may all pass through sewage: in fact, they all pass from us as excreta, in one way or other, they all admit of being made soluble, and I think I shall show that they may all be made solid. It is quite natural that in passing away with the excretion from the human body, they should enter into the sewage, and in that way, being distributed over a large surface, should impregnate water, and, in some cases, impregnate the air. It is with these poisons we have now to deal.

### DISEASES FROM THE ORGANIC POISONS.

The diseases produced by the organic poisons may be classed as follows:—

Small Pox.
Measles.
Scarlet Fever.
Diphtheria.
Typhus Fever.
Typhoid Fever.
Erysipelas.
Hospital Fever.
Puerperal Fever (or the fever which occurs to women in child-bed).
Cholera.
Yellow Fever.
Ague.
Glanders.
Boil and Carbuncle.
Infectious Ophthalmia.

## NATURE OF THE ORGANIC POISONS.

I pass now to consider, briefly, the nature of the organic poisons which produce disease.

The first point I would insist upon is, that in every case these poisons are in themselves specific. Each one has a specific property, always bringing out the same disease through countless ages. From the time when man was first attacked by them, on to the present time, I have no doubt that each of these diseases has been developed from, and has always depended upon one specific poison. Small-pox, for example, has as much depended upon one particular poison as the human race has depended upon the transference of one particular germ. That is a point to be remembered, but it is often forgotten. I must insist upon it, for the correct understanding of the whole question rests upon it.

And here, I must beg to remove an error which is very common indeed. It is a popular notion that the smells which emanate from sewage, and which sometimes are connected with poisonous sewage, and sometimes are not, that these odoriferous matters have something to do with the production of the diseases incident to sewage. Now, I may state that all the organic poisons are perfectly inodorous, have no smell whatever, and that no communicable disease ever depends upon the gases of decomposition, viz., carbonic acid, sulphuretted hydrogen, ammonia, phosphuretted hydrogen, or carburetted hydrogen. These volatile bodies are very distinctly perceptible if present, but they have none of them any power whatever to produce the fifteen specific diseases of which I have given you the names. You ask me, do they produce any effects? They do. Each one of them will produce a temporary effect. Air charged with one-fifth part in a thousand of sulphuretted

hydrogen will produce very decisive effects—will kill. The same with phosphuretted hydrogen. An air containing five per cent. of carbonic acid will in time produce serious effects. An air containing ammonia will produce singular effects: but here is the broad distinction between the effects produced by the gases and by the organic poisons; that directly we remove the subject from the gas, the symptoms will cease, while in the case of the organic poisons, the subject having once become affected by them, the symptoms will go on developing. That is the essential difference. The influence of the poisonous gases to which I have referred does not differ very widely from the influence of chloroform, or of any volatile bodies which produce sleep. Dr. Barker, of Bedford, most conclusively showed that the mere noxious exhalations from sewers produced only temporary effects. I had the extreme pleasure of taking part in his experiments, and of seeing him, in this very town, receive for the last great act of his life, the Hastings' Gold Medal, for his researches on the subject of which I am speaking. Dr. Barker carried out a series of experiments which we may call crucial. He made a chamber to hold live animals of large size. This chamber was ventilated from a sewer, and week after week animals were made to breathe the sewer air. Those animals all showed peculiar symptoms, something like the symptoms which we see in the close cottages of the poor during the winter time when there is great overcrowding, and a great accumulation of bad air. They sometimes showed symptoms of vomiting; they had heat of skin, quick pulse, and loss of appetite: but this was invariably the fact—that within an hour after their removal from the chamber they began to recover. The symptoms were from the distinct effect of the air from the sewer, and had nothing to do with the organic poisons which produce specific disease.

As regards the organic poisons themselves, and their physical properties I would, in the first place, point out that the great type of

them all is represented by the poison of any venomous snake. If I were going to speak of a family of plants, or a family of men, or a family of animals, I should take one great type, and then describe from that; and in presenting to your minds an idea of the organic poisons which produce the spreading diseases, I take the poison which is in the poison bag of a poisonous snake. If we puncture the poison bag, there exudes from it a peculiar fluid substance almost like clear gum water. That is the poison. If we gently dry that down, it becomes a darkish, somewhat powdery, yet half-glistening mass. A small bottle of snake poison in an isolated state is here laid before you.

Well, this substance may be mixed with water. If we then apply to it heat, we drive it off in the form of vapour. It is the great type of all the poisons which produce disease.

As regards the special properties of these poisons, they are all of them separable, and your President has told you that I have separated some of them. I have separated specially the poison of hospital fever. This is a secretion formed in the wound of a person suffering from the disease, and as it may be obtained in large quantities, it has been specially selected for the purpose of experiment. This poison, when obtained in large quantities, may be evaporated to the form of an extract or syrup, under which condition it looks as much like an ordinary vegetable extract as can be imagined. It produces, when dried, a substance resembling closely the snake poison. It admits even of being pulverised, and when it is introduced into the wound of a healthy animal, it produces precisely the same symptoms as those of the patient from which the poison was taken.

I have here a specimen of the poison of hospital fever, so prepared as almost to separate its active principle. It was extracted from the fluid of the peritoneal cavity of a lady who had been operated upon for ovarian

disease, and died of pyæmia. It was obtained for me, in the crude state, by Mr. Spencer Wells.

When the British Medical Association met in this town, I had the pleasure of recording the experiments on which these facts are based, and I have made researches on every class of animals in my reach, except man, on whom, of course, we cannot experiment.

The poison thus obtained may be introduced into the body in various ways, and I want to point out this fact—that as one can take an extract from opium, and from that extract obtain morphia, which is the active principle of opium, so we can take certain of these organic poisons from the body, reduce them to an extract, and from that extract produce a purer substance containing the true poisonous matter. This may be then communicated to another animal, and will give to the body of that animal the same poisonous property as was possessed by the poisonous substance first introduced. Again, the poison can be passed on and made to affect another animal, and so through a series of subjects.

In the course of some diseases, these poisons are separated by nature in an almost pure state. This is singularly the case with regard to the poison of small-pox, which poison escapes from the surface of the body, in an early stage, as a very fine vapour, and in that way the disease has been communicated. It has been communicated from men to sheep in that way; that is to say, the clothing from a man affected with small-pox has been wrapped round the nose of a sheep, so that the sheep must breathe through the fabric, and the disease has been reproduced. Again, the poison may be taken in a fluid form, as we very well know when we spread it by inoculation. We take it in the fluid form and put it into the body with the lancet, and clearly reproduce the disease. In a dry state, as in the scale of a small-pox patient, it is perfectly innocuous, till it comes into contact with water or with the secretions of the body; then it will become poisonous

Portions of these scales may be wafted into the mouth, where they will be moistened with the secretions of the mouth, and the disease will be produced. All the chemistry in the world could scarcely make the poisonous matter simpler than nature makes it in the disease small-pox. We may take the poison of small-pox, grind it down into a powder, and keep it in an almost pure state. That is not the case with all poisons, as with the hospital poison; but it is the case with the poison of glanders, of ophthalmia, and probably of the poison which forms in the blisters during erysipelas.

The poisons will all dry solid. There is no exception to this rule. In the solid state they are inert, but they are all capable of absorbing water again apparently after any lapse of time; and they admit of being charged with water almost to any degree: but as we progress in charging them with water, and diluting them with water, they entirely lose their active power. This accounts for a fact which was observed by the famous Dr. Fordyce in the last century. At that time, inoculation for small-pox was the rule; and Dr. Fordyce thought, "What if I dilute the poison? Can I produce a milder form of disease?" In fact, he was aiming in this way to produce what Jenner afterwards did produce by vaccination, namely, a modified small-pox. He took the poison of small-pox, mixed it with oil or water, and refined it to a considerable extent, and he inoculated patients with the diluted solution. He then found out this fact,—that, up to a given point, dilution made no difference, the poison always producing the disease; but beyond that certain point of dilution there was no disease at all produced by the solution,—not even a milder disease. This is in accordance with my experiments, from which I find that all the organic poisons retain their activity up to a given point of solution, and beyond that the water renders them inert. Through their extreme capacity for becoming watery, they lose their activity altogether. This accounts

for admixture with the water of rivers destroying the effect of these poisons. Suppose there is a large reservoir of water charged with cholera poison, that water will be poisonous to a certain extent. Then, as fresh charges of water keep coming in, the disease will go up to a certain height, and it will as suddenly stop again, because, after a certain point, the dilution has destroyed the action of the poison.

The poisons are transferable also by the vapour of water, and in this way they escape from the living body. So long as a person is affected with these poisons, and is giving off vapours at a certain temperature, he is poisonous. There is no doubt about that. The poison is mechanically distributed by the vapour, and the vapour is diffused in what I might almost call invisible spray. The poisons are mechanically carried with the vapour, and the vapour from the affected person may be absorbed by the healthy person by this means. But as soon as the body is dead, whatever the infection may be, the vaporisation having ceased, or a reverse process having been set up—that is to say, there being a condensation of vapour, as there often is on the dead body—the poisons are no longer infectious in the ordinary sense of the word. For that reason, persons who die from spreading diseases, are not contagious. I have made this a subject of special investigation among persons who have had to do with *post mortem* remains—undertakers and anatomists—and I cannot find a case in which the poison has been communicated from a dead body. The poison requires a certain amount of heat for its distribution, in order that it may affect those who surround the body.

As I have said, the poisons are harmless in their dry state, but they commence to resume their activity in water. In order, however, to ensure their continuous action, they need certain temperatures—certain degrees of heat; and in this respect one poison often differs materially

from another: and this marks out on the surface of the earth a specific range for some poisons. For instance, the poison of typhus fever is a very volatile poison indeed. It condenses with the greatest possible difficulty. The result is, that it only lives at a given low temperature. Directly we get to a temperature of 100 degrees, the poison ceases to present its effects. Hence, at a certain degree north of the equatorial line, the disease ceases, and does not commence again till we arrive at a corresponding temperature on the other side of the equator. There are other poisons which require a great degree of heat for their distribution. This is the case with yellow fever; and about at the point between the pole and the equator where typhus fever stops, yellow fever begins. If yellow fever be brought from a hot country to one of our own ports, it will not live. It may linger for a few days, but, as a rule, it will not extend.

The poisons are all capable of being destroyed by various means. They are all destroyed, as I have shown, by extreme dilution. They are all destroyed also by heat. I believe that a temperature of 212 degrees, that is, the boiling-point of water, destroys every member of the class. They are all destroyed again, by oxidizing agents. The mere exposure of them to moist oxygen destroys them rapidly. The mere exposure of them to ozonized, or electric oxygen, destroys them even more rapidly than ordinary moist oxygen. Exposure of them to chlorine is instantaneous destruction to them. Exposure to iodine is nearly as effective; and if the iodine can be diffused equally, it is as destructive as chlorine. Exposure to bromine leads to the same result. Exposure to nitrous acid has the same kind of effect, but not in so marked a degree. Exposure to sulphurous acid likewise produces destruction.

There is a curious fact having relation to the destruction of these poisons by sun-light. I find that snake poison is destroyed by sunlight. I had

some snake poison sent to me by Dr. Weir Mitchell, of Philadelphia. It was most active when it first came, and if taken on the point of a lancet and applied to a wound on a mouse or rat, it would kill the animal, with all the symptoms of snake poison. I exposed some of the poison to various treatments, to find if I could destroy its properties. I found I could destroy it by dilution with water, but could bring back its property by slow evaporation; and I found I could destroy it by the other agencies I have mentioned: but I was very much struck by the destruction of it by sunlight. This destruction did not depend upon the temperature, because another specimen kept at the same temperature in the shade, retained its effect. This accords with our experience as to the poisons of diseases. We know that on a bright sunny day emanations from sewers and stagnant pools become inert, and I have no doubt that bright sunlight is one of the means which nature employs for destroying the organic poisons. They have been found to lose their activity when they have been exposed to the sun either by intention or by accident.

Almost all the organic poisons are preservable by cold. We can keep them any length of time; in fact, I should think there is no limit to the preservation of them by extreme cold. We have seen this illustrated on a large scale in northern capitals, where the poisons have been locked up for months by the cold. The poison of cholera in St. Petersburgh has been locked up in the snow for a whole winter, and on the solution of the snow the poison has become active by being carried into the surrounding streams and taken into the drinking-water. The poisons are preserved also by many antiseptics. Common sulphur preserves them very well. The poison of hospital fever, which would undergo decomposition if left alone, I have been able to preserve for months by such means. Sulphur, creasote, and arsenic, hold these organic poisons in perfect steadiness, so that they undergo no change, but preserve their active properties.

Another fact with regard to these bodies is, that they are only poisonous during certain stages of their decomposition. This is a matter of very great moment in respect to them. With regard to the disease called hospital-fever, there is perhaps only one certain stage when the secretions really contain the poison. It was pointed out to me by Mr. Spencer Wells that the poison did not seem so destructive if it were removed when the patient was dying, and this seems truly the fact. There is a certain given stage in the process of the manufacture of these poisons when the secretions change, and at that point the poisonous matter becomes perfectly innocuous. We see this illustrated in a particular manner in what is called "dissecting-room poison." If I am called to make an examination of a dead body soon after death, and I get a prick from a knife which is being used, the results may be fatal: but in an advanced stage of decomposition a prick may be made, and no poisonous effect whatever be produced. The opinion of one of our most distinguished anatomists—the late Dr. Deville—was strong on this point. He considered that after six days no dead body brought into the dissecting-room was poisonous. The poison, perhaps, undergoes decomposition, and when destroyed by decomposition, its influence ceases.

### ORIGIN OF THE POISONS.

As regards the physical origin of the poisons, I may state, that the poisons are all derived from albumen, that "mother of the tissues," as it has been called, from which all the active structures of the body have been produced. Albumen is the nutritive principle in the yolk and white of egg. It is the mother of the organic poisons, as it is of the organic tissues, and we can take common albumen and transform it by decomposition, so that it shall itself become poisonous; one day, I believe, we shall be able to start from albumen, and produce any disease as from a new infection.

In considering the development of these poisons, it is a common error to suppose that they multiply from a germ, as offspring multiply from parents. We have heard epidemic diseases spoken of as diseases which spring from germs. But, in these poisons of which I speak, there is no approach to anything like a germ or seed. There is no kind of relationship betwixt the production of animal from animal, and the production of disease from disease in that sense. The poisons do not spring up in that way, but what occurs is this. Each particle of any one of these poisons brought into contact either with the blood of the living animal, or with certain secretions of the living animal, possesses the property of turning the albuminous part of that same blood, or that same secretion, into substance like itself. We are not masters of the precise physical steps by which this takes place, but we call the process catalytic. It is a change which we do not understand, but it is one by which a body is transformed by the presence of some other body which does not itself undergo change. The multiplication of the poison thus takes place through the power of the body itself—not through the propagation of germ from germ. For instance, I take some cattle-plague poison from the eye of one animal and put it into the eye of another animal. Presently there is a free secretion. The secretion soon is very profuse, and the animal is affected by the poison. If the inoculation has been deep, the whole animal will be affected, if it has not been deep only the eye at first will be affected. What is the meaning of that? It is not that the particle of poison has propagated a new particle as a man propagates a child, but it is, that the natural secretion of the eyeball has come in contact with a speck of poisonous matter, and immediately at that point where the speck of poison was, there is a change in the secretion. This process widens the circle, and more secretion pours out and more poison is produced; and the increase goes on, until in the end the whole body of the animal becomes

affected. Ultimately the poison is absorbed into the blood, and then the whole of the albumen becomes changed, and we have death. Again, take the case of diphtheria. A poison is formed in the throat of one person, and if that is drawn into the throat of another person, a central spot of secretion becomes changed in character, being transformed into the same substance as the poison which came in contact with it; then a further portion of the natural secretion becomes affected, and so in succession until the whole mucous surface may become charged with this matter, the body, as long as it can, feeding the change. This is the way in which these poisons make their progress.

As a general rule, the human body furnishes all the poisons that the human body suffers from, that is to say, there is a progression of poison from one body to another; and it would even appear that ordinary secretions may change and become poisonous without previous infection. We have had this remarkably brought out in the case of puerperal poison, where a secretion from the hand of the accoucheur has produced the puerperal fever. It also seems that in the case of peritonitis, or inflammation of the peritoneum, there is a secretion which may be carried on the hand of a healthy person, and produce the disease. Further, typhus may be produced by the overcrowding of persons in a room, through the vaporization of organic matter at a low temperature, and we can only account for some of the remarkable instances of gaol fever in the last century on this theory. With regard to cholera, I am bound to say that the whole history of cholera, so far as general facts are concerned, was most elaborately, originally, and beautifully written, by one of the most distinguished men of England, Dr. John Snow. But although he traced out the connection of water supply with cholera, he was too apt to believe that there must be an actual beginning of an epidemic with a case imported. There is however reason to believe that in the decomposition of sewage water,

cholera poison may be *developed*, and that we may thus have springing up *de novo*, an organic poison which afterwards, on being introduced into one particular body, becomes increased by the secretions of that body: thus an epidemic of cholera may have direct origination.

A singular fact has been brought out within the last two years; and it is this—that the vegetable kingdom appears to have the power of producing certain organic poisons, which afterwards affect man. This is specially the fact with regard to the disease measles. There is a peculiar vegetable spore or fungus cell which forms on wheat straw. During the great American struggle, Dr. Salisbury, who was with a body of troops at Camp Sherman, observed that a large number of men rose one morning with symptoms of measles. He found that the disease was very remarkably developed, and on making enquiry the men affected attributed their illness to the straw upon which they lay, which they said was of an unusual character, and had a very peculiar odour. The straw was enclosed in ticks forming, I presume, what is called the ordinary camp mattress. Dr. Salisbury removed from the straw certain portions of fungus; he had the courage to inoculate himself with the fungus, and he thus produced measles. He then inoculated his own wife, and then a mother and four children, and then a mother and two children, and produced in all the same disease. Dr. Kennedy, of Dublin, has found the same fungus in mouldy flaxseed meal, and has seen it produce the same effects. Two youths were at school; one had a bag of mouldy flaxseed meal, and he took a handful of the meal and threw it in joke in the face of the other youth. Very soon the youth thus played upon shewed signs of irritation of the eyes, running from the nose, cough, and difficulty of breathing, and next day he had the rash, and all other symptoms of measles. I know myself an instance in which it would appear very clearly that measles was produced by a straw-bed, which was infected with the same fungus.

This occurred in the family of a medical man. Here, then, we have disease produced by an albuminous body, derived from the vegetable world.

It is also clear that animals give us disease. For instance, the disease small-pox is connected with the disease of the horse called farcy. I have also seen a disease so nearly resembling farcy in the human subject, that it was hardly possible to distinguish it from the disease in the horse, from which it was derived.

As regards the mode in which organic poisons may be transmitted, they may travel in each of three ways. First, they may travel by means of sewage, as dry solid matter; and all the poisons do this constantly. Sometimes sewage matter dries. This has been remarkably the case in reference to the spread of cholera in India. In India, where there has been an encampment, the sewage is commonly formed into an embankment, and converted by the sun into pulverulent matter, which is wafted by the wind, and men marching to the windward of such a mass of matter have become affected with the disease. The poison is wafted into their mouths, and becomes active directly it is moistened by the secretions of the mouth. Disease may also be propagated by means of linen saturated with the secretions of patients and then dried. The linen is folded up, and perhaps taken into the country to be washed, and the person who unfolds it becomes enveloped in an invisible cloud of the poison. Again, the poisons may travel in water, or in water suspended in the form of vapour.

### MODES OF COMMUNICATION.

The mode of the entrance of organic poison into the body, although contact is always required, varies with the different poisons. The character of the poison changes the mode of its introduction to a certain extent. For instance, the poisons of three diseases—measles, scarlet fever, and typhus—are always inhaled. I do not know any way

in which they can enter the body, except by being breathed in. Experiments have been specially made with regard to all of them, by inoculation, but always with a negative result, with the exception of those remarkable experiments of Dr. Salisbury, where he seems to have got the poison of measles first hand, and to have produced the disease by inoculation. The poisons of small-pox, diphtheria, glanders, erysipelas, hospital-fever, and ophthalmia, require to be inoculated, or to be absorbed directly by the part affected. Perhaps there may be an exception made here in favour of small-pox, which belongs to both classes, and which either may be inhaled or inoculated. But those other diseases I have just mentioned, — diphtheria, glanders, erysipelas, hospital fever, and ophthalmia,—require direct contact. Take for an example, the disease ophthalmia. A number of children are lying in the ward of a sick hospital; one of them has ophthalmia, and the poison from the eye of that child is carried away by the air, and wafted into the eye of another child. There is thus direct contact between the poison and the eye, and a pure eye disease is the result. The poisons of cholera, yellow fever, typhoid fever, ague, and perhaps of boils, seem always to be swallowed poisons, taken in mainly through water-supply; and the poisons of cholera, yellow fever, typhoid fever, and ague, may be called, specifically, the poisons of sewage. They are poisons which enter the body only by being taken into the mouth. None of them can be propagated by inoculation. The propagation of yellow fever by inoculation was tried by the late Dr. McKinnell. He inoculated himself and several men with the excreted matter of yellow fever, without producing any effect. Typhoid fever poison is also without effect when used by inoculation. These poisons, therefore, mostly travel in a fluid form, and must be swallowed to be effective. They may, nevertheless, travel for short distances as fine dust, and they may travel distributed in water in the form of vapour.

## DISPOSAL AND DESTRUCTION OF ORGANIC POISONS.

I could dwell largely on many points connected with the distribution of poisons in the way I have described; and, of course, I could touch upon many statements which we have heard to-day: but I have tried not to dwell upon any of the papers which have been brought before the Congress. I shall leave the facts as they are, contenting myself with referring, as my next point, to the best means for the disposal of the organic poisons in the household, when they have entered it.

Presuming that the poison is in a state of vapour in the household, that is to say, there is a patient suffering with one of the diseases that produce the poison, and that he is hot, and is freely distributing the disease-matter around him by means of the vapour from his body, what is the best thing to do to prevent infection? There can be no doubt that the best process, and the truest process of all, is active ventilation. In the experiments of Dr. Barker, no kind of destructive body brought into contact with the poisons destroyed their action like ventilation with pure air. The ventilation should be accompanied by sunlight; and patients suffering from contagious diseases should be placed, not only where there is a constant current of air, but free sunlight. In most cases, too, we may consider that heat has a distinct effect in distributing the poison and destroying it. I very much doubt, whether in a large hospital built specially for typhus, there could ever be any infection, if the patients were kept at a temperature of 100 degrees.

The temperature should be kept up, as well as the ventilation. This will do good in two ways,—by securing a more rapid supply of air, and so increasing the ventilation, and by tending to destroy the poison instead of intensifying it, as cold does. There are other means which

assist the destruction of the poisons. Certain agents oxidize or destroy the poisons. A very simple plan of effecting this destruction, is to diffuse iodine through the sick room. If the temperature of the room is high, the iodine only requires to be exposed. We take a little iodine (the ordinary metalloid), place it in a box, and cover the box with a slip of muslin, and place it in the room. At a temperature of seventy degrees, we can diffuse a drachm of pulvarized iodine in twenty-four hours; and we may thus keep a room actually charged with the iodine, and the air, therefore, in an active condition, for any time we like, without much trouble or watching. In extreme cases, as in small-pox, it is a very good plan to place the iodine in a saucer, hold the saucer over a spirit-lamp or candle, and diffuse the vapour by the direct application of heat. After iodine, comes chlorine; but chlorine is dangerous, because, if it be diffused through the room, one never can tell but that a current of it may be brought into direct contact with the patient, and he may inhale it in too large a quantity. In using chlorine for disinfection, I invariably have it prepared in small two-drachm bottles, and send it to the house in order that it may be used bottle by bottle. In a room that measures ten feet high, and is, say about ten feet square, one or two of the bottles of chlorine may be placed at a distance of six feet from the bed of the patient, and the gas allowed to diffuse. In the course of an hour the chlorine will be equally diffused through the room.

This is the only safe way of diffusing chlorine, and it is a very elegant way, and one which a nurse may manage. I know of no disinfectants at all that approach chlorine and iodine, for the purpose of destroying the organic poisons when they are in a state of vapour. I have sometimes used the permanganate solutions in the form of spray, making use of a spray-tube in the process. I have diffused ethereal solutions of iodine, and ether charged with ozone, with effect. Never, however, let us forget the utility of air, heat, and sunlight, for the

destruction of the organic poisons. We use even iodine and chlorine without effect, till we get sunlight, air, and heat.

When the poisons are in a fluid state, as when passing from the bowels in cholera, or typhoid fever, what is the best way of destroying them? I have no hesitation in saying, from a large series of experiments, that nothing approaches iodine for this purpose. As soon as the excreted matter passes from the patient, we throw iodine on it, and, perhaps, a little charcoal, and it should never go out of the sick room without being treated with iodine. I have inoculated animals with organic poisonous matter before treating it with iodine, and after treating it with iodine, and in no instance have I failed to find that the matter was poisonous before being treated with the iodine, but never poisonous after being so treated. This iodine process of disinfection is childishly simple. The infected matter may be directly oxidized through iodine, for the iodine really acts in the end as an oxidizer.

When the poisons are in the form of dry substance, spread upon clothes, very simple but important rules require to be observed. It has been remarked, in reference to cholera especially, that as a disease it is peculiarly fatal to laundresses. In the little town of Tamworth, some years ago, the epidemic broke out, and I think nineteen laundresses died successively. Why? For this reason. The clothes of the cholera patients, and the bedding saturated with the poisonous excreta, are thrown into water, according to the common practice. As soon as the clothes are put in, the water is reduced far below boiling temperature. Then the persons who are going to wash the clothes take hold of them and move them about, and the poison, not being destroyed at a temperature below 212 degrees, rises with the vapour, and is taken into the body. It is rarely convenient to put articles of clothing properly and at once into boiling water; therefore, the best practice is to

put them first into cold water. They are not poisonous if you know how to manage them. You can put them into your pocket and carry them about, if you know how to treat them. In cold water (under fifty degrees) they remain quite harmless. To destroy the poison, the clothes should either be taken out of the cold solution and carried into a room, the temperature of which is very high—say 300 degrees, and there, with nobody in the room, and with a good shaft, be allowed to dry quite through, so that when dry, they may be exposed to a high temperature: or, what is readier, a great cauldron of water should be placed over a fire with a large chimney, and, when the mass of water is rapidly boiling, the clothes should be thrown into it, and the chimney draught so closed that no one is exposed to the vapour. I have carried this plan out for several years with clothes from scarlet fever, diphtheria, and typhoid fever patients, and I have never seen any propagation of the diseases, when these precautions were adopted.

I have only one other subject to treat of. Perhaps you will consider it the most telling. It is the question, What is the best way to apply sewage to avoid the propagation of these poisons? Putting aside economy, I think there can be no doubt that that town would be most happy in regard to its health, that should have a proper water supply derived from one source, and a drainage well flushed, but not over large, and a conduit to take away, as it was produced, every particle of sewage into the sea. I am not speaking of the economy question at all. I am speaking of the health question. The town thus placed, would, I say, be a model town. We have had such towns: we have such towns. We have a town in which one disease—cholera—has been introduced many times, but has never spread, and I do not believe can spread. Other diseases, those which depend upon the mere volatilization of poisons in small rooms, spread in that town. I am referring to the town of King's Lynn, in Norfolk. In the reign of

Henry VI., in the year 1423, the people of that town went seven miles away from the town to a stream called the Gaywood, and brought down a clear supply of water to the town, and that stream has been supplying ever since, and flushing the town into the river. There have been several cases of cholera carried into the town, but the disease has never spread. But still, while saying this, I am convinced that science has so far advanced that she ought to be able both to exclude the poisons from the sewage, and at the same time to apply the sewage for the uses of the human family. How shall the economist and sanitarian best work together? It would be compatible with health if the sewage could be perfectly locked up in a common reservoir. It would be compatible with health if the sewage were perfectly decomposed. Under these circumstances, however, it would cease to be valuable manure. It would be compatible with health if the sewage could be spread over a wide area. It was said to-day in the Congress, that no disease was caused by the utilization of sewage. That is not correct, for in an Asylum I know, typhoid fever broke out simultaneously with the utilization of sewage, and ceased when the sewage distribution was discontinued. The sewage, if distributed, should be distributed away from a town, where there can be no contamination; and it should be distributed in such a way that the ground itself should be one of Mr. Moule's earth-closets on a large scale. In that case, we should have a perfect application of the sewage. I am not advocating any particular plan; but as one who looks at the sanitary side of the question, I am merely pointing out the demands which must be made of anyone who is studying to combine economy with science-health.

You will observe that I have held, in this lecture, mainly to the health side of the question. There are two aspects of the question —usefulness and health. I have kept mainly to the subject of

health, perhaps from habit; perhaps, because I think that, after all, national health is national wealth; and, lastly, because,—while I very much admire labours which have for their object the utilization of sewage,—I know that Nature is the master of all, and that the man who is endeavouring to utilize sewage, under the notion that useful matter must otherwise necessarily be lost, is labouring under a very serious delusion. Nature ordains that nothing ever can be lost. If we cannot give sewage to the land, the sea will have it, and indirectly the fish will have it, and we may have the fish: for whatever man may do, he cannot disturb the motion of the earth, nor change its balance a single grain. Nature, Almighty conservator! from age to age ever keeps up a continuous supply for demand; and from the very womb of death spring, in perpetual line, the most perfect forms of life.

THE END.