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THE

CHOLERA-GERM:

WHEN, WHERE, AND WHY INFECTIOUS.

BY

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TRANSLATED AND EDITED

BY

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LONDON:

WATERLOW & SONS LIMITED, PRINTERS, LONDON WALL.

1893.

PRICE ONE PENNY.

TRANSLATOR'S NOTE.

BY rendering into English DR. JAEGER'S latest views on the cholera question I hope to accomplish two objects. Those who, like myself, have studied DR. JAEGER'S writings for years past know that they contain an extraordinary wealth of observation and knowledge in connection with natural science, especially fitting him to give the clear explanations afforded in the following notes on the cholera-germ. In view of the possibility of the cholera epidemic spreading in Great Britain this year, DR. JAEGER'S description of the nature and habits of the cholera-germ and of its capacity to infect will be of especial interest to our medical and sanitary authorities, and will do much to allay unreasoning panic on the part of the public. A clear understanding of the subject can hardly fail to infuse courage into men's minds, and to induce the sanitary authorities to lose no moment, to spare no effort, in removing the conditions under which alone, as DR. JAEGER points out, the cholera-germ can multiply and become infectious.

My second object is to endeavour to give to the English-speaking public, who only know DR. JAEGER as an advocate of woollen clothing, a glimpse of scientific attainments which will surely cause him at no very distant day to rank as one of the master minds of the nineteenth century.

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April, 1893.

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WHENEVER a cholera epidemic occurs in Europe, those who are regarded as experts separate into two hostile camps, one of which asserts, and the other denies, that cholera is infectious. The former party may be termed Contagionists, and the latter Anti-Contagionists, and each side is supported by admittedly high professional authorities. At present Professor KOCH heads the Contagionists, and Professor PETTENKOFER the Anti-Contagionists.

The controversy here referred to is no idle, theoretical, professional question, which the laity can tranquilly leave to medical men. On the contrary, it is a matter of the greatest practical importance to the public; for the Contagionists are the party who, on the occasion of every cholera epidemic, declare war on all public arrangements, and even on the most ordinary liberties of mankind, and who claim to be entrusted with the whole police force of the State for the purpose of forcibly controlling the actions of their fellow-citizens. This is no small matter.

The truth can only be with one of the two parties, and want of full knowledge of the subject is the reason for the difference of opinion. Neither PETTENKOFER'S latest utterance, nor the recently published reply of the KOCH party, has done anything towards supplying the special information without which each side is unable to furnish a complete solution of this all-important question.

I will first try to show the position of affairs, as exemplified in the persons of the leaders of the two parties—KOCH and PETTENKOFER.

The last-named is the veteran of scientific cholera investigation, and is credited among scientific men with most knowledge on the subject. Moreover, he has taken the best method, by studying the cholera as a whole, and in its relations with the entire scheme of nature. The facts on which these relations are founded are admirably set forth by PETTENKOFER:—

Cholera, as an epidemic, depends throughout its whole course in a very great degree on what PETTENKOFER calls the tendencies of time and place, and these may be summed up as the state of the underground water. 1. Cholera is by no means universal, only appearing in localities possessing a certain formation of the ground—*i.e.*, where the ground is pervious, and not unless there is underground water. 2. Even then cholera does not appear at all seasons, but is governed by a factor which varies at times, namely the rainfall—*i.e.*, it depends upon the height of the underground water, which again depends upon the rainfall. With the rise of underground water the danger of cholera diminishes or disappears; and when the underground water sinks, in consequence of dry weather, the danger grows.

This is PETTENKOFER'S theory respecting the underground water, and the facts are quite correct; but the theory does not afford full information on the subject, particularly in two respects.

1. PETTENKOFER himself has never really contested—on the contrary, he has admitted—that two additional factors are necessary to cause an epidemic of cholera: first, a living germ, which is transported through the general intercourse of mankind (this factor is termed by PETTENKOFER, for brevity, X); and second, an individual tendency (this he terms Z). The above-mentioned tendencies of time and place he terms Y. Now PETTENKOFER has not further studied X or Z, but has mainly confined his investigations, based on statistical methods, to the factor Y. Of the two other factors he assumes that Z (the individual tendency) is a known one, and the germ, or X, he describes as "unknown," although existing. PETTENKOFER'S latest writings show no change in this position of his views on the subject.

2. A second important omission is that PETTENKOFER has

made no endeavour to study the interdependence of these factors, or to show in what relation the factor Y which he so clearly recognises stands with the two other factors; and thus the explanation of factor Y is inevitably wanting. To state this more exactly: The individual tendency to disease, the factor Z, and the cholera-germ, the factor X, are both animate objects; what is the connection between the height of the underground water (factor Y) with these two animate objects? Does factor Y influence the individual tendency or the character of the cholera-germ, or both; and how? On these points PETTENKOFER throws no light whatever. All his expositions, even the most recent, leave it a complete riddle how the height of the underground water comes to be one of the three combined factors to which cholera epidemics are due. He only says, and there he is right, that Y plays a very important part, but he does not say what part.

Now comes KOCH, and produces the factor X, the cholera-germ, which PETTENKOFER had treated as existing but as "unknown," and subjects it to the exact experiments of the schools of medicine. And what is thereby achieved? Something, of course; but PETTENKOFER is right when he says that only by experiments on human beings can we find out what we want to know; and for that reason PETTENKOFER long ago made the experiments upon himself recorded in the newspapers at the time. PETTENKOFER is further correct when he asserts that KOCH ignores the factor Y, and has made no attempt to clear up the relation between his factor X, the cholera-germ, and PETTENKOFER'S factor Y. But PETTENKOFER is wrong when he maintains that it is impossible to do this with the bacterial theory, as I will presently prove. True, KOCH cannot explain the relation, for the simple reason, as I shall show, that he does not possess the requisite zoological knowledge.

The second point which KOCH also leaves quite unnoticed and unexplained is the factor Z, the individual tendency. Literature comprises many contributions on the subject, but they never rise above the level of an incoherent casuistry; no explanation has been given. Particularly is the relation between factors X and Y left unexplained.

Briefly, the case stands as follows: PETTENKOFER recognises and represents factor Y, KOCH factor X; factor Z has been left

out in the cold, and both to PETTENKOFER and to KOCH the saying applies—

Die Teile hat er in seiner Hand,
Fehlt leider nur das geistige Band.

[The various parts within his hand he finds ;
Alas! he lacks the spirit force which binds.]

When there is such a gap between the two, space may be found for a third, and this space I feel that I am in a position to fill.

1. These gentlemen have not studied factor Z, while my considerable hygienic researches, extending over many years, in connection with human beings, were directly concerned with what is called the individual tendency. In this direction I possess as great and as long-standing experience as PETTENKOFER with factor Y and KOCH with factor X, and I can at once give the correct name to this factor Z—viz., "Self-poison." Without a knowledge of the self-poisons, a subject to which I have given very extensive study, an understanding of that which is called tendency to sickening or to infection cannot be attained.

2. The disease bacteria are parasites, and it will not be disputed that zoologists, and next to them, botanists, are most versed in all that concerns parasites. It is a fact that until quite lately the subject of parasites was almost exclusively confined to the sciences of zoology and botany, for the large parasites of human beings which were then known have such slight capacity for inducing disease that pathologists were content to leave the study of them to zoologists and botanists. Even the *trichina* was not of sufficient importance to effect an alteration in this position of matters. A change first began with KOCH, who founded bacteriology, which involves the study of disease-inducing minute parasites. The great mistake, however, was at once made of pursuing bacteriology as a special study, without previously acquiring the necessary zoological-botanical knowledge respecting parasitism. The technical zoologist—and I hope that even my opponents will admit my claim to be one—possesses in the numberless observations and in the comprehensive biological investigations carried out by hundreds of men (I need merely name LEUKART, SIEBOLD, KUCHEMEISTER, VAN BENEDEN, and others), splendid material for the most exact instruction respecting parasitism. Moreover, the zoologist has at his disposal a means especially well

adapted for his purpose in the shape of the comparative method, which is in great measure, although quite mistakenly, neglected by medical science. In the schools of medicine there is, of course, only comparative anatomy; but I have for years widely studied comparative biology (the science of life), as is shown by my publications (I would here only refer to my article on parasitism in *Trewendt's Encyclopedia*, zoological section, vol. 6, and to my writings, *Stoffwirkung in Lebewesen* and *Entdeckung der Seele*). The following observations have been in part already made by me in these earlier publications; but, firstly, I can supplement what I said there, and I must do so in view of the special subject of the cholera; and, secondly, I can improve on what I have already written. The perusal of a quite recent publication, confined strictly to zoology (Loos: *Das Schmarotzertum in der Tierwelt*, Leipzig, 1892), was the cause of my again occupying myself more closely with the question of infection. One remark in particular in this work led me to reflect as hereinafter set down. This was to the effect that the egg of an intestinal worm, in the condition in which it is at the time that it leaves the host, is incapable of germinating in a host of the same species, but must first undergo a change of abode. This is a fact which may be learned from all zoological books, and which of course I had long known, but without my having drawn from it the deduction which I will at once proceed to describe.

When, incited by this remark, I reviewed my zoological acquaintance with the relations of parasites to their hosts, and compared therewith what is known respecting disease germs, the following—for the cholera question, highly important—law of parasitism became clear to me, namely: The contrast between external parasites which exist on or in the skin and its structures (*epizoa*, *epiphytes*), like lice, fleas, itch-mites, etc., and internal parasites which lodge in the intestines or other internal organs of their host (*entozoa*), such as intestinal worms, consists in the following:—

1. The external parasites are able to pass directly over to another host—a person suffering with lice or from the itch can at any time directly communicate infection; with tapeworm, infection can never be direct, and is only possible in roundabout ways, the most important of which I here cite: (*a*) By way of

change of host, with or without change of generation. The best known example is that of the tapeworm. With certain exceptions, so rare that they prove the rule, it may be said that only carnivora (and, of course, omnivora, like Man), have tapeworms, and the tapeworm's egg only germinates in a being which, as contrasted with the first host, is herbivorous : for instance, the egg of a dog's tapeworm will germinate in a sheep or hare, that of the cat in the mouse, that of human beings in swine or cattle. Thus is constituted a so-called alternation of generations : in the new host no tapeworm is produced, but a *cysticercus ;* and this reposes in the flesh of the intermediate host until the latter is swallowed by a flesh-eater; then the cyst falls off and the tapeworm grows apace. In addition to a change of the host, a change of the organ takes place : the tapeworms live in the intestines ; their intermediate forms are never found in the intestines, but always in the flesh. Of other worms which are found in the liver the intermediate forms are invariably discovered elsewhere. Similarly the *trichina* undergoes this double change : as a muscle parasite it enters into the new host, and becomes an intestinal parasite, and only fructifies as such ; then its brood enters again into the muscles. What is the reason of this ? Nothing of the kind happens with the *epizoa.* (*b*) Many roundworms (*ascarides*) do not need an intermediate host, but their eggs are just as little able to germinate directly in the same host : these must first manage to be deposited in the damp earth or in the slime of puddles of water, there to creep out as tiny worms, wholly unlike their parents, and therefore separately named by earlier zoologists as *rhabditis*, *dracunculus*, and so on. Not until they have in this form begotten several generations can they wander again into the host whence they originally proceeded. The internal crustacean parasites of fish act in the same way ; their eggs only develop in the open water, and the young remain a considerable time in the water before they enter the body of a fish. (*c*) Numerous experiments with roundworms have shown that if the worm's eggs while still fresh are introduced into the human intestines, they never germinate. For a long time it was sought to discover the intermediate host, but it is now established that none is necessary ; only, the eggs must be exposed for some time in the open air to the influences of the

weather until they have attained capacity of germinating. It has further been found that even when an intermediate host is necessary, as with the tapeworm, the transfer to the host does not for the most part take place directly; the eggs must for some time previously have been exposed in the open air to weather influences. Here we are reminded of the eggs of the silk-moth. These develop into caterpillars if they have been frozen. If the eggs pass the winter in a room which is free from frost, it is useless to place them in spring in the breeding apparatus. Conversely, if immediately after the eggs are laid they are placed in a freezing apparatus, the caterpillars at once appear, whereas otherwise the eggs would have remained unhatched through the winter. (*d*) Ichneumon flies, parasitic *diptera*, etc., live as larvæ in a caterpillar; the mature insect leaves this abode to remain for some time in the open air, and only deposits its egg again in the host, differing from the round-worms in that, with the latter, the developed creature is an internal parasite, while the egg or embryo lives in the open air. (*e*) The fifth example is afforded by the small white thread-worms which are found in the rectum of children. No one of the multitude of eggs which these worms deposit develops in the rectum; but when in consequence of the irritation the child scratches itself, the eggs of the parasite are caught by the finger-nails, and thus are sometimes conveyed into the mouth and stomach. Here they find the necessary new ground to develop, and to make their way, as young worms, to the rectum. This is a case of the change of organ mentioned in section (*a*), but without change of host.

It results from the above-named facts that the external parasites can pass directly to another host of the same species, while the internal parasites require a change of ground or of sojourn, and must spend a larger or shorter time in the new locality before they, *i.e.*, their offspring, can return to the original host. This new locality is either a living creature of a different species (intermediate host), or is in the open air, and in some cases it is a different organ of the same host.

2. The second contrast between external and internal parasites is that the former, *i.e.*, their germs, can endure light and air, while the latter are creatures requiring water and dark-

ness, and are very sensitive if exposed to dryness and light. Even if, as eggs, they can bear a certain degree of drought, this is very dangerous to them when they are in a state of activity, and light has generally a similar effect upon them. Therefore, where a locality in the open air is chosen for the change of abode, and not an intermediate host, this locality must be a wet one, and generally a dark one as well. All germs which do not reach a locality complying with these conditions are lost for the purpose of maintaining the species.

3. This leads us to consider a third contrast: The intestinal worms possess an incredible fertility, far exceeding that of the parasites most closely allied to them, while the external parasites in no way differ in this respect from allied types which live free. This contrast is connected with the one previously cited. The maintenance of their species by external parasites which endure light and air, and which do not require a change of abode, is so assured through the intercourse of their hosts, that nature finds the ordinary degree of fertility to suffice. For the intestinal worms the necessity of a change of residence constitutes a leap in the dark, and nature meets this by the formation of enormous quantities of germs.

The explanation of these contrasts between external and internal parasites furnishes us with two rules governing all living things—animals and plants—the investigation of which was a subject of my biological studies:—

(*a.*) One of the various laws of alternation may be thus briefly described: Every living thing whose surroundings are not sufficiently associated with open air conditions vitiates the atmosphere of its abode by its specific secretions, so that it can only exist there in a sickly state, if at all. In this way aquatic animals corrupt the water in which they live, and the creatures living in or on the ground corrupt the soil; the ferment germ affects the fermenting liquor, stalled animals corrupt the air in their stables, and human beings vitiate the atmosphere in their rooms. If the creatures whose atmosphere is thus corrupted remain therein, they must either die or be reduced to inactivity, and become incapable of multiplying; in short, the maintenance of the species or of the individual is at stake. The only remedy is a change of the medium in which they live, or conversely,

as in agriculture, a change of the crop. The cause of stagnation of activity is the satiation of the creature with its self-poison, and of this it can only be purged in a new unvitiated medium. When, on the other hand, a creature lives under conditions which permit it to throw off its specific self-poison freely in air or water, the necessity of purging, and therefore of change of abode, is no longer felt. The external parasites are in the latter condition, and therefore never fall into a state in which they lose their vital, or infectious, capacity; whereas the internal parasites are irremediably exposed to this laming of the faculties, and are thus forced to take up a temporary change of abode. Where this is not at once possible, as in the case of the *trichina* and of *cysticerci*, all that the parasite can do is to wait in a latent state of existence until released by the consumption of the host as food. Where, on the other hand, it is possible for the parasite to change its abode, sooner or later this is automatically effected, a fact which affords a fourth contrast between the two kinds of parasites. The external parasites, such as lice and fleas, do not of their own accord abandon their host; the internal parasites, particularly those which infest the intestines, leave so soon as they become lamed in their activity from the causes above described.

(*b.*) Impregnation of the tissues. This is a many-sided subject, and can only be partly dealt with here. We say that persons are "seasoned" when poisons like arsenic or tobacco have no effect on them, owing to their being impregnated to a certain extent with the poison in question; or when, through being frequently stung by bees or mosquitoes, they are so impregnated with the insect's poison that it no longer hurts them. Vaccination, of course, works in a similar way. To any one who interests himself in these matters, with which every medical man should be acquainted, I recommend my publication *Stoffwirkung in Lebewesen*, Leipzig, 1892. This cessation of venomous effect, due to specific impregnation, is incidental to all parasites, but with the difference that external parasites suffer no disadvantageous consequences therefrom. The internal parasite is also not directly injured, but indirectly the impregnation annuls the difference between it and its host, diminishing its capacity to germinate in its host, and, more particularly, to induce

disease in the host, which is for us the main question; further, there is the injury which is caused to the internal parasite by its own self-poison. The joint effect of these conditions is that its germs cannot develop in the same host, but first require a change of abode, in order to be purged of their self-poison.

After these explanatory remarks respecting large parasites, we can turn to consider the minute parasites, especially the animate disease germs. These accurately follow the general rules of parasitism, and display the same contrast between external and internal parasites.

1. The minute external parasites are always capable of infecting, and comprise the germs of the, properly speaking, infectious diseases, such as smallpox, measles, scarlet fever, etc., the bacteria of which, it is true, have partly yet to be discovered. These germs require no change of abode, and are therefore not concerned with external natural conditions, and may be compared with lice, fleas, and wood-lice, which merely depend on the individual tendency in so far as some only settle on healthy hosts, while others select hosts which are diseased.

2. The internal parasites, especially the intestinal, such as the cholera and typhus bacilli, as also, for instance, the germs of malaria, are not directly infectious; they must pass some time in a different kind of medium from their previous host in order to resume their capacity to infect.

3. The second form of contrast also applies to the minute parasites. The germs of infectious skin diseases are proof against the effects of light and air, *i.e.*, desiccation and light do not injure them. It is otherwise with the internal bacteria. It has been known for some time that the cholera-bacillus is very sensitive to desiccation, and now Professor BUCHNER, of Munich, has shown by experiments that this bacillus cannot stand the light, and only flourishes in the dark. A zoologist could have confidently predicted that without experiment, and I now assert the same thing of the bacteria of typhus, dysentery, and diarrhœa with vomiting.

4. The internal bacteria possess the same astounding fertility as the intestinal worms, especially those of cholera—the estimate of the number of bacilli in a cubic centimetre of cholera evacuation is ten milliards! To a zoologist this one fact alone

is sufficient evidence of the uncertainty of existence of the cholera-germ outside the body, and of its difficulty in getting back into a new host.

5. In the fourth point, also, congruity is shown : just as the intestinal worms must of their own accord one day make an exodus, so the diseases induced by intestinal bacteria die out spontaneously ; whereas, for instance, the undoubtedly bacterial leprosy is as tenacious of existence as are itch-mites and lice.

In this connection, and merely by the way, I may point out that in acute skin eruptions there is a change of organ. We may be sure that the disease germs live first in the inner organs ; they then enter the skin, and the situation becomes as follows : Through the first sojourn of the germs the inner organs of the host have attained immunity, and cannot be further attacked by the germs, so that these diseases heal spontaneously. The germs which have broken out in the skin are, however, in consequence of their position on the surface, capable of germination in the inner organs of a new host.

The parasites in the air passages occupy a sort of middle place ; the incessant breathing action is the cause that symptoms of laming are not nearly so distinct in their case as with the intestinal bacteria : the lungs are better ventilated than the intestines. But want of space forbids my entering further on this subject.

The foregoing has now supplied us with the main clue to the dispute which has arisen between the Contagionists and the Anti-Contagionists, and also clearly shows the mistakes which have been made on both sides. First I will criticise PETTENKOFER.

As already remarked, all that he says about factor Y is correct, but he does not explain it, nor does he know in what relationship it stands to the two other factors. This explanation I am able to supply.

The cholera-bacilli, like the eggs of the tapeworm and liver-fluke, are impotent, in the condition in which they pass from the intestines of the host, to infect a person ; they require a temporary change of locality, and to there undergo mutations, in order to regain capacity to infect. They evidently need no intermediate host, as the tapeworm does, but resemble the eggs of the roundworm in that they must reach some open spot where three conditions must exist, viz., dampness, darkness, and

as complete freedom as possible from competing or otherwise hostile creatures, especially from the bacteria of putrefaction, which experiment has amply shown to quickly destroy them.

This open spot is, in the first place, the ground, and hence follows the necessity of a local tendency. As the germs cannot stand light and air, they are lost if they remain lying on the ground, and in the water the light kills them. The local tendency therefore implies, as PETTENKOFER has correctly discerned, pervious ground; on rock and clay soil the germs quickly perish.

The second condition is dampness. This clears up two points: (*a*) In dry ground, even when it is pervious, the cholera-germ dies of drought. Therefore, as PETTENKOFER rightly says, underground water must be there, and the germ must find its way to it. (*b*) The periodic tendency is also thus partly explained: The dampness of the soil and presence of underground water do not simply depend upon the local permanent character of the soil, but also on the periodically, as well as locally, changing quantity of the rainfall; and hence arises the periodic tendency.

If it be asked in what way is the cholera-bacillus induced or enabled to alternate from the human body to the underground water, and *vice versâ*, the answer is that its specific nourishing matter forms the connecting link, and this is human excrement. Only such underground water as is polluted with this matter, especially such as has acquired a diarrhœic odour, furnishes to the cholera-bacillus the necessary condition in order to recover its capacity to infect. Yet in the actual drains and cesspools where there is abundance of the matter in question the cholera-bacilli quickly perish. This apparent paradox can only be explained by one who is acquainted with that most important biological law, viz., that "concentrated matters exercise a laming, even deadly, effect upon living creatures, while diluted matters have an animating effect." That which so soon destroys the cholera-bacilli in the drains is not merely the struggle for existence against the bacteria of putrefaction; they are stifled in the over-concentration of their nutritive matter; whereas in a fluid which contains a diluted solution of this matter the converse obtains, and they actively multiply. With plants it is just the same: manure is an excellent nutritive medium for plants, but no plant can grow in manure alone.

In addition to the explanation thus afforded, we derive two important practical suggestions:—

1. If a town stands above underground water, the most important practical problem which the sanitary authorities have to solve is to prevent human excrement from reaching the underground water. When PETTENKOFER freed Munich from typhus, he at first imagined that the disease was conveyed in the drinking-water, which at that time was pumped in Munich from the underground water; and he induced the town, at great expense, to institute a water supply from a distance. He was, however, not a little embarrassed to find that in spite of this precaution typhus still prevailed. He then procured the adoption of a second vast and costly measure. A system of drainage was introduced which prevented the sewage from entering the underground water, and then PETTENKOFER triumphed over the enemy —for Munich has since been free from typhus. The rise or fall of its underground water is immaterial, for it is *pure*.

When, on the basis of his practical experience, PETTENKOFER does not admit that cholera and typhus may be spread through the drinking-water (impure wells), he seems to somewhat overshoot the mark. It is undoubtedly true that in conduit or well water, properly cared for and kept pure, koprophagous bacteria, like those of cholera and typhus, find much too little nourishment to sustain them. But drinking-water contaminated by fæcal matter is as dangerous as polluted underground water; and KOCH is certainly right when he attaches responsibility for the last epidemic of cholera in Hamburg to the condition of the water supply.

In a case of cholera-diarrhœa which came under my personal notice some years ago, no one in the house or in the town was infected; but in a house in a neighbouring village where the patient's clothing and bedding were thoughtlessly sent to be washed the regular Asiatic cholera broke out, and nearly the entire family perished. Here the water used in washing played the part of the underground water; it was the factor Y in which the cholera-bacilli recovered their capacity to infect. If the clothing, etc., which was of plant fibre, was not actually soiled with the patient's evacuations, it contained, in addition to cholera-bacilli, the fæcal self-poison which plant fibre attracts

and absorbs; perhaps in the same water diarrhœic children's things were washed, constituting a solution, even though very diluted, of the specific nutritive matter which would amply suffice to enable the bacilli to multiply and to become capable to infect. An additional impulse would be afforded by the warmth of the water used for washing. This clearly shows that in cleansing and disinfecting objects which have been soiled by cholera secretions a damp and warm method should be avoided; the objects are free from danger while they are dry, but if they are wetted and allowed to remain wet for some time, the result, when not *all* the germs are killed, is precisely the reverse of that aimed at; the surviving germs multiply and become infectious. Any object which is allowed to remain damp for a considerable time, whether it be an article in the wash, or the floor of a room, can become what PETTENKOFER has termed the factor Y for the cholera-bacillus. On the other hand, the dry treatment is always free from danger.

But now we come to a third point. The cholera-germ, in order to remain alive and to regain its capacity to infect, must absolutely reach the underground water; yet, in order to again induce cholera in a human being, it must re-ascend. PETTENKOFER has not, so far as I know, concerned himself with this latter incident, and has therefore given no explanation of it.

The gap has been filled by the botanist Professor NÄGELI, in his book, *Die niederen Pilze in ihren Beziehungen zu den Infektionskrankheiten*, Munich, 1877. The full particulars must be, of course, obtained from the book itself; here the following will suffice:—

Bacilli cannot directly attain to the surface from the underground water or from the wet soil; this only becomes possible when the underground water retires, leaving the germs behind upon particles of earth, together with which they dry. In this condition they no longer adhere closely to the earth or stones, but take the form of disengaged dust, and are sucked up by rising streams of air such as are induced in houses through heating the rooms. Thus the chief point, rightly described by PETTENKOFER as the periodic tendency, is explained, namely, its dependence on the rainfall. With heavy rain the underground water rises, and the soil becomes thoroughly wetted; the main

route by which the cholera-bacteria can reach the surface is thereby closed. One way, it is true, remains open to them—that of the underground water which supplies wells, springs, and rivers; but in the two latter they soon fall victims to the light, while the opportunity of reaching the dark recesses of wells is very slight, and, when the ground is at all compact, very doubtful. This is the reason why cholera becomes less general step by step as the rainfall increases; conversely, when the rainfall diminishes and the underground water sinks, leaving more and more layers of ground dry, a cholera epidemic gains in virulence. No exception can be taken to this explanation by NÄGELI. That, in addition, the penetration of cholera-bacilli to the drinking-water conduits is a means of infection is, in my opinion, an absolute certainty, apart from the confirmatory statistical facts, for here the cholera-germ may find all the conditions which it requires in order to regain its capacity to infect; and when PETTENKOFER is unwilling to admit this, he is certainly in error.

Now I pass to a criticism on KOCH, whose error is much more dangerous than that of PETTENKOFER.

KOCH, as is well known, breeds the bacilli in an artificial fluid nourishment, in the darkness of a breeding-oven. With these bacilli he makes experiments on animals, and deduces from his experiments the behaviour of the bacilli when they enter human beings. He thus arrives at quite erroneous conclusions respecting the infecting capacity of the bacilli. The reason for this is that he is not acquainted with the law of parasitism explained above, and therefore does not know what he is doing. From the facts that the bacilli multiply in the nourishing fluid, and that animals can be infected with the bacilli thus artificially bred, he concludes that the bacilli as excreted by the cholera patient can infect if they reach the intestines of another person. This is wrong. The nourishing fluid in the dark oven is a *new abode*, and the bacillus undergoes in it the same regenerative process which, in nature, it requires to undergo in the darkness of the underground water; and KOCH altogether overlooks that his breeding apparatus exactly corresponds with PETTENKOFER'S factor Y. Between KOCH'S artificially bred bacilli and the natural bacilli, such as the cholera patient excretes, there is the capital difference that the former are capable to infect and the latter

are *not*. The evacuations of the cholera patient are in no sense infectious, any more than are those of a sufferer with worms, although they may contain a multitude of the parasite's eggs. This explains the well-known fact that the attendants on cholera patients are very seldom infected. KOCH is therefore wholly wrong in this most practically important point. The bacilli first become dangerous when they undergo regeneration in certain places in the open air, or in the breeding apparatus. This constitutes in practice an enormous difference. Further, KOCH quite fails to see that his experiments on animals involve a change of abode for the germ. An animal is a new abode for a parasite of human beings, and it cannot be concluded, from what the parasite does in a new abode, that it would similarly behave in its old abode, *i.e.*, in a human being—a proof how deceptive experiments with animals may be.

PETTENKOFER has come much nearer to the truth by studying cholera in its connection with nature. KOCH has been led by his study of artificial cholera to lay down rules which are even worse than shooting at sparrows with cannon-balls ; he fires off his cannon at nothing at all, for that is what the general disinfection in times of cholera epidemic amounts to. Compared with the enormous destruction which nature provides for the cholera-bacilli, the disinfection practised by men is ridiculous.

We come now to the individual tendency, PETTENKOFER'S factor Z. Without referring to what is well enough known respecting the measures of defence which the body is able to oppose to the bacilli, I may remark in connection with the experiments made by PETTENKOFER and EMMERICH on themselves that infection resulted in their case (1) because the bacilli were not in their fresh, natural state, but had been artificially treated so as to be capable to infect ; (2) because the power of defence inherent in the body did not sufficiently act ; still, PETTENKOFER only contracted a cholera-diarrhœa. His conclusion that this proves that the bacilli selected for the experiment were not the actual cholera-germs is erroneous, and is due to his inability to explain the factor Z—KOCH being in the same position.

The difference between a regular cholera patient and one who has only cholera-diarrhœa throws a light on the subject of the individual tendency. The former displays all symptoms of a

thorough poisoning, which, according to VIRCHOW, strikingly resembles arsenical poisoning ; these symptoms are absent in cases of cholera-diarrhœa.

This clearly shows that the poison which produces Asiatic cholera does not originate from the comma-bacillus, but its source is to be found in PETTENKOFER's factor Z—the individual tendency. *There is no specific cholera poison ;* the symptoms of poisoning incidental to Asiatic cholera are engendered through *self-poison.*

At this point three questions have evidently to be touched upon :—

1. Panic. It is universally admitted that a state of panic constitutes in an important degree a tendency to cholera, but no one who is ignorant of that most remarkable and most easily to be studied self-poison, the decomposition of albumen in the body induced by terror—which I term, for brevity, "terror-matter" (*Angststoff*)—can comprehend the cause. A person suddenly seized with terror presents, exactly like a cholera patient, the appearance of violent poisoning, with diarrhœa and sickness, often actual vomiting, convulsions, and great exhaustion. In actual fact it is a case of poisoning. The shock induces a decomposition of matter in the centres of the nervous system, and the formation of a fæcal-smelling, highly poisonous decomposing matter, which penetrates the tissues. The consequences are : (*a*) a condition of violent poisoning ; (*b*) this "terror-matter" forms a source of nourishment for the cholera-bacillus, and incites it to such rapid multiplying that the water is drained from the tissues of the patient, who mostly succumbs. That is the beginning and the end of Asiatic cholera. Whoever, like PETTENKOFER and EMMERICH, has the courage to knowingly swallow cholera-bacilli, is not affected by terror, and therefore does not contract cholera.

2. A second well-known tendency exists when diarrhœa is already contracted, providing the bacillus with quite the same or very similar nutritive matter as in the last case ; the diarrhœic evacuations of a terrified person have almost the identical odour which characterises those of a person who is diarrhœic from some other cause, and the influence upon the bacillus is in both cases the same.

3. If terror and diarrhœa constitute more the acute tendency, the latter is the cause of a kind of chronic latent tendency. It is known that numerous cases of ordinary diarrhœa frequently precede an outbreak of cholera. Now this occasions people who are uncleanly, and who live in the bad air of dirty quarters of a town, to store up in their tissues the evil odours of human diarrhœa, in the way which I have described in several of my publications on the subject of self-poisoning as one of the most common tendencies to disease. To become seasoned to bad air is only possible when the poisonous air has been stored up in the tissues. The intrusion of the comma-bacillus gives an impulse to the sudden liberation of these poisonous odours in the body, and the position then resembles that of a person affected with terror or with actual diarrhœa. In PETTENKOFER'S experiment of swallowing the bacillus this tendency was also absent, but not entirely in Professor EMMERICH'S case.

The well-known fact that the men who attend to the sewers do not contract Asiatic cholera attests the accuracy of this explanation. When a person is seasoned to bad air, his body becomes impregnated with its poison; but when he *remains* in bad air this poison is not easily set free in the body. On the other hand, it may easily be set free when he is transported into good air. The sewer-man is in the former position; in spite of his being so impregnated with poisonous odours, these are not set free, because he remains in the bad air.

This throws light upon a mistake which is often made in the treatment of cholera patients. When a patient, accustomed to live in the foul atmosphere of a cellar-dwelling, is suddenly removed into the relatively pure air of the hospital, the protection which the surrounding bad atmosphere afforded him is all at once withdrawn, and the stored-up poison in his tissues is more certain to be set free in the body. If ever it be necessary to leave a sick person where he is, it is necessary with cholera patients.

Those who understand the science of odorous matters may make the following deductions from the remarkable absence of odour and taste in the evacuations, resembling rice-water, of a cholera patient:—

1. A confirmation of what has been stated above, that the poison which induces the symptoms of Asiatic cholera is not a

product of the bacilli. There are poisons which are almost free from odour and taste, but they are so exceptional that they prove the rule; and there is no ground for assuming that the product of the cholera-bacilli forms such an exception, but, as already stated, the assumption is all the other way.

2. The special matter which nourishes the cholera-bacilli is precisely the fæcal odour in the intestines, which they so thoroughly consume that the secretions become odourless.

3. The investigations of the schools of medicine respecting cholera have established that the cholera-bacillus does not exist in the blood and the tissues, but only in the intestines, that it is, therefore—speaking zoologically—no flesh or blood eater. The expert in the science of odorous matters needs no experiments in order to ascertain this fact. He knows, what is notorious to every layman, that all eaters of flesh and drinkers of blood are distinguished from creatures who do not consume flesh or blood—whether they are parasites or animals—by the especially malodorous evacuations of the former; and he concludes that a parasite whose evacuations are so odourless as those of the cholera-bacillus cannot, under any circumstances, consume flesh or blood. The cholera-bacillus therefore only consumes the contents of the intestines of diarrhœically diseased people, and instinctively seeks the diarrhœic odour of human beings.

This gives the second main clue to the explanation of the symptoms of Asiatic cholera, and the position now stands out clearly as follows:—

1. Factor X is KOCH'S comma-bacillus. As this, like all intestinal parasites, is not capable, in the state in which it leaves its host, to infect, it must regain this capacity in a new abode, under certain conditions of time and locality outside of a human body, and this necessitates PETTENKOFER'S factor Y.

2. Even if the bacillus is in a condition to infect, it can only gain a footing in the human body when the natural bacteria-destroying elements proper to every living creature are wanting or work faultily. If the footing is gained, the result depends chiefly on two considerations: (*a*) People who have for some time lived in an atmosphere vitiated by diarrhœic secretions, and whose tissues are therefore charged with this form of self-poison, especially when, in addition, "terror-matter" is set

free in the body, suffer from acute self-poisoning (Asiatic diarrhœa), which under certain circumstances may cause death in the same way as terror has been known to kill, and this before the parasite has fairly commenced to take effect (*cholera sicca*). If these self-poisons are absent, the so-called cholera poisoning is absent too, and the result is a harmless attack of diarrhœa. (*b*) The quantity of nourishment available for the bacilli: the danger is great in proportion to the quantity present of malodorous diarrhœic evacuations, because these enable the parasite to multiply enormously.

3. The cholera-bacillus is distinguished in principle from the bacilli of other diseases in that (*a*) it does not attack the bodily substance of its host; (*b*) it therefore produces no poisonous ptomain, and thus the injury which it does to its host is not of a poisonous, but of a mechanical nature: if it finds sufficient nutriment of the kind which it requires, it multiplies with such fabulous rapidity, and in such amazing proportions, that the tissues and the blood are drained of their water. This explains the great extent to which the disease depends upon the individual tendency: if there is no such tendency there will merely be a harmless, not even malodorous, diarrhœa. But when the tendency is there, a highly dangerous illness ensues, which runs its course with lightning rapidity. The outbreak is sudden, and recovery is sudden, if death has not intervened.

It will be conceded that in the foregoing I have given a complete explanation, in every direction, of the apparently contradictory facts respecting cholera, such as neither KOCH nor PETTENKOFER has even approached, and it only remains to add a few words from the practical point of view.

The cholera is infectious, but not directly so. It is therefore right so to treat the evacuations of cholera patients that the disease-germs shall, as far as possible, be prevented from seeking a temporary new abode, where they may recuperate their powers of infection before again entering a human body; anyone seized with cholera should therefore be placed under professional care, but must remain where he is until the necessary steps have been taken. On the other hand, the planless pursuit of bacteria which may somehow have escaped, the annoying of healthy persons, and restrictions on travelling and goods traffic,

are measures which are wholly superfluous, considering the mighty destructive powers which exist in nature at large, and in the human body, to deal with these germs. Moreover, the impossibility of entirely preventing the germs from being carried about renders the injury and expense involved by these measures quite unjustifiable. That I have long held this view is sufficiently known to my readers, and I expressed myself to the same effect last September. There is a widely spread revolt against the violence exercised, and against the destruction of property entailed by measures which are contrary to healthy common sense and to the plainest laws of humanity. What can be done to prevent a repetition of these violent measures if the cholera revives, as it certainly will do? That question deserves to be thoroughly discussed, for whatever is to be done must be done soon.

In India the British have to deal with the cholera all the year round, but it never enters their heads to in consequence upset or stop all the trade and traffic between India and Europe. They treat the cholera like any other infectious disease, and let it take its ordinary course. The cholera, moreover, has never come direct from India to Europe, but invariably travels by the land route through anterior Asia, where the towns are huge pigsties. Cleanliness and courage amply suffice to keep the cholera within bounds; disinfection and quarantine excite panic, and then the trouble is there. The cholera resembles a wild beast. Whoever has the courage can tame it, but it tears the coward to pieces.

I have before me the report recently published by the Hamburg Sanitary Commission on the cholera epidemic, containing plans showing the houses in which cholera broke out in a certain district of Hamburg. The dwellings are classified, and I will give a few extracts from the report:—

1. Cellar-dwellings.—The filth in these was frightful, and only to be explained by the general dampness and darkness, as well as by the class and the number of the inhabitants. In some of them the closet was without any ventilation except into the kitchen.

2. Large houses in flats, occupied by numerous families.—In one such house out of eighteen cases of cholera fifteen were in

the middle rooms, which are almost without any light or fresh air, the closets being pitch-dark and quite unventilated.

3. Dwellings in side streets, with separate closets—as distinguished from those for the common use of a number of families.—The back rooms of the dwellings looked on to a yard, and it was only in these that the disease was virulent. The odours of a large cellar in which potatoes were stored, of stables on the ground floor, of a dung-pit in the yard, of the closets, were unable to get away, and permeated these rooms.

4. Dwellings in alleys, with one closet for common use, the smells from which penetrated the living rooms; in one instance eleven persons were attacked by cholera, and three died.

5. A case is given in which two closets in a yard served, during the late epidemic, for about seventy persons. The rain-water ran from the roofs of these closets into the yard; the walls were covered with fungus, which in some parts was over a foot high. The condition of these places may be imagined from the fact that the men appointed to disinfect them were prevented by the pestilential odour from entering until they had poured a jugful of carbolic water on the floors. In twenty-four dwellings, occupied by one hundred persons, sixteen cases occurred, five fatal. Of these, all except two were in dark back rooms. The closets spread a pestilential odour over the whole yard.

The Commission states that where there was not over-crowding cases of cholera were rare, while it raged where the dwellings were closely packed.

I will here quote two instances which have recently appeared in the press, and which confirm my assertion that the individual tendency to which the contracting of cholera is mainly due is caused by the storing up in the tissues of these foul odours with which the body has become impregnated by dwelling in a vitiated atmosphere.

In the *Oberschlesischen Anzeiger* of 2nd September, 1892, a manufacturer named MICHLER, at a meeting of the Hygienic Society in Neisse, is reported as saying that when the cholera broke out on his estate in 1866, and several hundreds of persons were rapidly seized with it, he appealed for help to DR. SCHINDLER, the successor of PRIESSNITZ, of cold-water-cure fame. Before DR. SCHINDLER arrived ten of the patients who had been treated

with medicine had perished; but out of three hundred treated in the following manner *not one was lost.*

The patient was wrapped in a bath-sheet previously thoroughly soaked in water, and was strongly rubbed by two attendants over the whole body. After the body had began to transpire, a jug of cold water was again poured over the sheet, and the rubbing was resumed until the body again became warm, when the body was once more strongly rubbed with a dry sheet, and a dry linen bandage was placed round the stomach, over which came a flannel bandage. The patient was then made to take a walk of at least an hour in the open air, and invariably returned sound and well. It could at once be recognised whether a person was suffering from cholera by the odour which proceeded from the body during the rubbing. When transpiration began the odour resembled that of human excrement, and was so powerful as to greatly inconvenience the attendants.

In the Hanover *Sonntagsblatt* of 6th November, 1892, is an account of a clergyman's experience among cholera patients at Hamburg. He says: "I had no conception previously of such a pestilential stench as I encountered during the epidemic. The odours which proceeded from alcoholic patients were simply intolerable, and we had to adopt special measures to counteract the stench, as sprinkling with carbolic water was of no use here."

When these facts are considered, together with those respecting the houses in which cholera raged in Hamburg, and when it is remembered that the evacuations of cholera patients are almost odourless, there is little room for doubt as to what constitutes the factor Z, *i.e.*, the individual tendency to this fearful disease. This pestilential odour which proceeds, not from the evacuations, but from the exhalations of the skin and lungs, and from the sweat of the patient, cannot reasonably be anything else than the collection in the tissues of the foul odours described above as pervading the cellar-dwellings, etc. Was I not right when I said years ago, "Disease is stench"?

With which of the three factors termed by PETTENKOFER X (the germ), Y (local and periodic tendencies), and Z (individual tendency), should the law chiefly endeavour to deal?

1. Clearly laws can only be laid down for mankind; nature has her own laws, and will not be dictated to by men, and

factor X is, of course, a part of nature, while Man is mainly responsible for factor Z, which can therefore be reached by the law. Factor Y is only partially concerned in infectious diseases, and is influenced by Man and nature combined, as the underground water only becomes factor Y when polluted by Man. The law can only reach that for which Man is directly responsible, and the endeavour of the State to deal with the cholera epidemic must therefore, in the first place, be directed to factor Z, in the second place to factor Y, and only in the last instance to factor X.

2. Which is the most favourable, most promising point of attack when an evil has to be extirpated? Surely the root of the evil; and that this is in all epidemics factor Z, the individual tendency, is beyond all doubt. Without Z factors X and Y can effect nothing. If it be objected that Z without X cannot produce an epidemic, I reply that Z is already an evil, irrespectively of X, and its removal is of itself a duty imposed upon humanity. Those who thus possess a tendency to disease are practically powerless to resist the attack of any epidemic; secondly, they are susceptible to all the diseases peculiar to enfeebled constitutions; and thirdly, they are in a state of physical degradation, which is a misfortune both for them and for their fellow-creatures.

What is the object of laws dealing with epidemics? Clearly to advance the general welfare and perform a humane duty. The question is, therefore, what course to pursue in order to attain this end most completely.

3. By combating factor Z we shall secure the removal of chronic, not merely physical, but also moral and social evils, and the abatement of all diseases without distinction; moreover, a general permanent benefit will be conferred on an entire class of people. If, on the other hand, our efforts are mainly directed to combating factor X, the result to mankind, as the last cholera epidemic showed, will be not a benefit, but a calamity, a letting loose of vexatious rules against a number of people who have done no harm, and who derive no benefit from these rules, but injury and chagrin instead.

4. Laws must be just—*i.e.*, where they punish, command, or make responsible they must hit the exact person who is really

responsible, and of whom the law can lay hold. All this is practicable in dealing with factor Z. *The guilt of causing the cholera calamity rests with the rent-sweaters*, whose wicked greed allows such conditions as are described above to exist on their property, breeding epidemic disease. These, who are the really guilty parties, can be caught and punished, while all who are innocent remain unmolested.

When measures are directed against X, it is impossible to avoid that great numbers of wholly innocent people are at least inconvenienced, if not punished and subjected to actual injury or loss. This is not justice.

The foregoing should leave little room for doubt that factor Z is the real object to be aimed at by those who are concerned in the prevention of cholera, and I recommend to their notice the practical suggestions of the committee from whose report I have quoted. They request the Hamburg Senate to use every endeavour, without loss of time, to formulate suitable laws respecting buildings and dwellings, as well as to cause rapid and cheap means of transit to be provided, so that the area for the people's dwellings may be widened, and the city thus be relieved from overcrowding.

The question then arises, Who is to see that such laws are obeyed? Here I may allude to my experience in the Isle of Wight, when I spent a fortnight there with my wife in the spring of 1890. We stayed in a boarding-house, and the first thing which caught my eyes when the front door was opened was a certificate, signed by three members of the Local Board of Health, that all sanitary arrangements in the house were in order.

This reminiscence leads me to mention a second observation which I made in the Isle of Wight, and which concerns not only factor Z, but also factor Y. We wandered all over the island in every direction, and nowhere, not even in the smallest village, was a place to be seen which human beings had defiled. This struck me all the more forcibly because in my spring excursions beyond the Alps I was accustomed to meet with just the opposite state of things. In a little place where we baited the horse I was astonished to find a cleanliness and an absence of odour in the somewhat primitive closet of the small inn such as I have never met with under similar circumstances in Germany.

A box containing ashes and a little iron shovel was at hand, and was evidently regularly used. I learned that in every district, however small, there is a Board of Health which keeps the strictest watch over public cleanliness. No doubt there are places in the large towns and elsewhere in England which are by no means perfect in respect of cleanliness, but I believe that such places must be sought for; in my, certainly not very extended, wanderings in and around London I never encountered offensive uncleanliness. Such filthiness as is found in many (although not in all) places in Italy does not exist in Germany; but I have nowhere seen in my own country such cleanliness as I met with in England. Undoubtedly strict cleanliness, especially in all public places and resorts, is the primary and most important defensive measure against every epidemic; and the first care of legislators must therefore be to institute such ordinances and arrangements as will not merely serve for special cases, but will be a permanent influence for good. These precautions have the advantage, too, that they are effective against factor Y as well as against Z; for only where public and private cleanliness is wanting can the underground water become a regenerative medium for disease-germs.

Legislation devised with a view to the constant combating of factors Z and Y will meet with the glad assent of every sensible person who has at heart the welfare of his fellow-men. But a law such as is now proposed in Germany, for organising a kind of bacilli-hunt by the authorities; which makes no attempt to deal with the rent-sweaters to whose greed these breeding-places of epidemic are due, except to require them to do some disinfection; and which is to be an exceptional measure, only coming into force when an epidemic has broken out, should meet with general and resolute resistance.