Further experiments on the disinfecting powers of increased temperatures / by William Henry.

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FURTHER EXPERIMENTS

ON

THE DISINFECTING POWERS

OF

INCREASED TEMPERATURES.

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IN the Phil. Mag. and Annals, for November, I described a series of experiments, which established the following conclusions:—

I. That raw cotton, and various kinds of piece-goods, manufactured for clothing from that or other materials, sustain no injury whatsoever, either of colour or texture, by exposure for several hours to a dry temperature of nearly 212° Fahrenheit *.

II. That the infectious matter of cow-pock is rendered inert, by a temperature not below 140° Fahrenheit; from whence it was inferred that more active contagions are probably destructible, at temperatures not exceeding 212°. This proposition it was obviously within the reach of experiment to determine. But I had intended to have resigned the inquiry, to those who are engaged in the practice of medicine, as more within their province than my own; when the appearance of malignant cholera at Sunderland determined me immediately to extend the investigation. If that disease be communicable from one person to another, there appeared ground for hope that any new facts or principles, respecting contagion generally, might be brought to bear upon this particular emergency. If cholera should be proved not to be so communicable, there still would remain many infectious maladies, to which any newly acquired knowledge of the laws of contagion might admit of beneficial application.

Of diseases generally allowed to be contagious, I could obtain access to two only, typhus and scarlatina. The former malady does not, however, answer to all those conditions which are required to render it a fit subject of experiment. It is less distinctly marked, than many other diseases, by characteristic appearances; and it is judged to exist, from a collection of symptoms, each of which is occasionally wanting, and each of which, when present, admits of such an infinite

* The temperature, I have since found, may in most cases be safely raised forty or fifty degrees higher.

variety

variety of shades, as to render its discrimination extremely difficult and uncertain. But a still stronger objection to typhus, as a source of evidence on this subject, is, that by no inconsiderable number of writers it is denied to be contagious at all. On this topic a controversy has been carried on, into which I decline to enter. My own conviction, founded on very extensive observation of the disease during more than twenty years of private practice, and still more as physician to the Manchester Infirmary, Dispensary, and Fever-wards, is that, *under certain circumstances*, typhus is decidedly contagious; although, by strict attention to cleanliness and to free ventilation, the effluvia issuing from the sick may be so diluted and carried off, as to be rendered almost harmless.

My determination to reject the contagion of typhus as a subject of experiment was, however, changed, by learning from Mr. Johnson, the resident clerk of the Fever-wards in this town, that there was at that time in the house a singularly well-marked case of the disease. The physician also, to whose charge the patient (a female, æt. 19) had devolved, assured me that he had not, during the last two or three years, met with a case which he could more confidently pronounce to be contagious typhus. Its severity was proved by its terminating fatally, notwithstanding the most assiduous attentions, on the fourteenth day of the disease. During the night, between the tenth and eleventh days of the malady, a flannel jacket, made without sleeves, was placed in contact with the body of the patient. On the following day, it was replaced by another; and that, on the day after, by a third; each of which was worn by her for several hours. The first waistcoat, after being submitted to a temperature of 204° or 205° Fahr., for an hour and three quarters, was kept beneath, and within twelve inches from, the nostrils of a person engaged in writing during two hours. The second, after being heated in a similar manner, was worn next the body of the same individual for two hours. The third, after exposure to heat, was kept in an air-tight tin canister for twenty-six days, with the view of giving activity to any contagious matter, which might possibly have escaped decomposition. It was then placed within twelve inches of the face of the same person for four hours; a gentle current of air being contrived to blow upon him, from the flannel during the whole time. No injurious effects were experienced.

The negative results thus obtained are only, I am well aware, entitled to that proportional share of weight, which would have been due to them, if they had formed a part of a numerous series of experiments. For the reception of contagion, even

even by a person situated within its sphere, depends so much on predisposition, and on other circumstances, that a much larger induction of facts would be necessary, to establish the absence of *fomites* in any case like the foregoing. I do not, therefore, lay much stress on so limited a number of facts. It may be proper, however, to mention, that, during the first trial, the person subjected to it was much fatigued by previous exercise; and that at the close of it he had observed an unbroken fast of eight hours,—a state of the animal system extremely favourable to the efficacy of contagion, if any had been present.

In Scarlatina, however (including both *scarl. simplex*, and *scarl. anginosa*), we have a disease admirably adapted for furnishing the necessary evidence. No one doubts of its being infectious. Perhaps, indeed, of all the diseases with which nosologists have arranged it (the *exanthemata*), it gives birth to the most active and durable contagion. The interval, between exposure to infection and the commencement of the disease, is unusually short, and may be stated at from two or three, to six days. When the infection has been received, the malady, produced by it, begins to be contagious before the scarlet efflorescence appears; and it continues so even after the subsequent desquamation of the cuticle. Every medical practitioner of much experience must have been baffled in his attempts to dislodge it from families, in which it had gained a footing. In such cases, its revival at distant intervals of time has been sometimes traced to clothes or bedding, which had been carelessly laid by, without being sufficiently purified. In the state of *fomites*, this species of infection has lain dormant for many months. Dr. Hildenbrand, for example, relates that he carried the infection in a coat, which had not been worn since his attendance on a scarlatina patient a year and a half before, from Vienna into Podolia, where the disease had till then been almost unknown*. Generally speaking, too, scarlatina is a distinct and well characterized disease; and whenever it is otherwise, the doubts may commonly be removed, by comparing it with the prevailing epidemic.

These considerations rendered me extremely desirous to try the disinfecting powers of elevated temperatures over the contagion of scarlatina. It fortunately happened that in one of the wards of the House of Recovery, a patient (a female, aged nineteen, of the name of Gerrard) was suffering under that form of the disease, which has been termed *scarlatina*

* *Dict. de Med.* xix. p. 156.

anginosa.

anginosa. The symptoms, in the judgment of the attendant physician, as well as in my own (taken in conjunction, too, with the previous history of the case), left no doubt of its nature. To make the most of this excellent example of the malady, a succession of flannel waistcoats were worn, each for several hours, in contact with the body of the patient, and were then put into dry bottles, which were well corked, tied over with bladder, and laid by for use. Other opportunities of obtaining waistcoats, similarly infected, soon occurred, in the cases of Sarah Gerrard, a younger sister of the first patient; of William Johnston, æt. eleven; and of Robert Green, æt. fifteen. In Johnston, not only were the appearances quite unequivocal, but he was the last of four children, (not all of one family,) who had been infected, in regular sequence, by communication with each other.

1. A waistcoat, which had been worn all night by the elder Gerrard, a day or two after the appearance of the scarlet eruption, was heated four hours and a half at 204° Fahrenheit, and on the 8th of November was applied to the body of a boy, æt. six years. No symptom having shown itself on the 15th, a second waistcoat was then applied to him, which had been worn more than twelve hours by Johnston on the second day of the scarlet efflorescence, and then heated at temperatures varying from 200° to 204° Fahrenheit, during two hours and three quarters. After an interval of twenty-two days the boy, who still continued to wear the same waistcoat, remained perfectly well.

2. A waistcoat, which had been worn twenty-two hours by the elder Gerrard on the fourth and fifth days after the appearance of the eruption, was on the 19th of November heated three hours at 204°. It was, after this, worn by a girl, aged twelve years, till the 30th, without effect. Another waistcoat, which had been worn by Sarah Gerrard, was then substituted, but without any effect ensuing.

3. A waistcoat, put on by Sarah Gerrard on the second day of the efflorescence and worn by her three days, was applied, Nov. 19th, after it had been heated two hours at 200°, to the body of a boy aged ten years. On the 30th a second waistcoat, which had been worn by Robert Green during the first and second days of the eruption, and which had been kept in the disinfecting apparatus at 204° during one hour only, was substituted; but no symptoms of infection have appeared.

4. A waistcoat, which had been worn by the elder Gerrard seventeen hours on the 7th and 8th of November, (the second and third days of the eruption,) was kept closely corked up in a bottle till the 25th, then heated four hours and a half, at temperatures

temperatures varying from 200° to 206°, and applied to a girl aged thirteen years. On the 30th of November, no effect having been produced, another waistcoat was substituted, which had been worn eleven hours by Johnston on the third day of the efflorescence, and then disinfected by a temperature of 204° applied during two hours. No symptoms of scarlatina have shown themselves in this case.

In all the foregoing instances, it was ascertained by the most careful inquiries that the children, to whom the disinfected waistcoats were applied, had never been affected with scarlatina, and were therefore liable to that disease. The children were attentively examined every day, in order that no slight symptom might pass unobserved*.

The experiments, which have been related, appear to me sufficiently numerous to prove, *that by exposure to a temperature not below* 200° *Fahr. during at least one hour, the contagious matter of scarlatina is either dissipated or destroyed.* To me it seems more probable that it is *decomposed*, than that it is merely *volatilized;* because cow-pock matter, though completely deprived of its volatile portion at 120°, is not rendered inert by temperatures much below 140°. I did not, however, consider it as either necessary to the proof, or justifiable, to determine, with respect to the contagion of scarlatina, either the lowest temperature, or the shortest time, adequate to the disinfecting agency; for these points, which are of no practical importance, could not have been decided without the actual communication of the malady. Still less necessary, and less justifiable, should I have thought it, to have proved, by exciting the disease, that, the waistcoats, as taken from the patients, were impregnated with the contagion of scarlatina.

It may, I am aware, be urged that the induction would have been more satisfactory, if founded on a greater number of instances. But experiments, of the kind which have been related, are attended with so many difficulties, as to forbid their multiplication beyond what is absolutely necessary. Not to mention other obstacles, it is far from easy to find young persons in every respect unexceptionable for the purpose;—to insulate them, as was done in these instances, from all casual sources of infection;—and to keep them under the watchful care of observers, qualified to mark even indistinct symptoms that might arise, and to apply the proper remedies. It must be acknowledged also, that the inference from the

* It is due to Mr. Edward Johnson, resident clerk of the Manchester House of Recovery, that I should acknowledge his valuable assistance, especially in the care with which he superintended the disinfecting processes.

destructible

destructible nature of the *fomites* of scarlatina, to that of other contagions, remains analogical; and that experiments are still wanting to extend the proof to other known species. The argument, however, in its nature cumulative, has acquired a great increase of probability by the step which has been made, in showing that the power of heat is not merely exerted over cow-pock infection, but extends to the active and virulent contagion of scarlatina.

The circumstances, under which the experiments were conducted, render it, I think, demonstrable *that the disinfecting agency belongs to heat alone;* for the receptacle, in which the infected waistcoats were placed, having in every instance been closed, change of air could have had no share in the effect. The phænomena, then, are reduced to their simplest form; and the results put us in possession of a disinfecting agent, the most searching that nature affords;—one that penetrates into the inmost recesses of matter in all its various states. As a disinfectant of articles which are capable of imbibing and retaining contagion, heat is greatly superior to the vapours or gases used for the same purpose; inasmuch as the transmission of the latter may be stopped by a few folds of compressed materials; while heat, if time enough be allowed, finds its way in spite of all obstacles. To avoid being misunderstood, I must however repeat, that it is to the destruction, by heat, of contagion existing in substances technically called "susceptible," that I limit the proposal:—for instance, to infected clothing of every description; to infected bedding and bed-furniture of every kind that would be spoiled by washing; to trunks and other packages brought by travellers from infected places; and to merchandise, whenever it can be shown, or rendered highly probable, that such merchandise has been in the way of imbibing contagious matter*.

This is not the fit occasion for obviating anticipated difficulties, arising out of the consideration of practical details. A few of these have been candidly stated to me, and have led to actual trials, chiefly as respects time and labour, the results of which have been satisfactory to the objectors themselves. The remaining element of calculation, the expense of appa-

* After taking great pains to obtain information, I have not been able to satisfy myself whether any, and what amount of danger exists from the presence of contagion in merchandise. There is one article, however, which is more likely than any other to be a vehicle of infection, viz. *old rags*, of which large cargoes are constantly imported into this country.

Letters, which are often rendered almost illegible by fumigation, might be disinfected in this way, if closed, not with sealing-wax, but with wafers. Writing-paper, I find by experiment, begins to turn brown a little under 300°; but it still retains its texture, and the ink is not materially changed.

ratus

ratus and fuel, I am unable to supply; but much observation of the use of steam, on a large scale, induces me to believe that the cost of producing and of applying it to this purpose would be far more than compensated, by the great and manifest advantages of abridging the duration of quarantine,—perhaps of supplanting it altogether. I do not, however, consider steam as an essential vehicle of heat for disinfecting purposes. Temperature, in whatever manner it may be raised, will doubtless be found adequate to the effect. It is probable that a current of air, heated within a safe point, on the plan invented by the late ingenious Mr. Strutt, of Derby, and now applied to so many useful purposes in manufactures and domestic economy, might accomplish the end at much less expense of time and money*. All that I attempt is to furnish the principle; its application I leave to experienced engineers in this and other countries. After the most attentive consideration, I can myself discover no objection to the execution of the plan, that may not be surmounted by a reasonable share of zeal and perseverance; and without the exertion of those qualities, no important improvement was ever carried through all its stages,—from its first suggestion to its final and complete establishment.

That the quarantine laws of every civilized country require to be carefully revised, and to be entirely re-modelled *by mutual agreement between different nations*, does not admit of a doubt. In their present state, they are both oppressive and inadequate. They demand observances that are of no use, and overlook others that would be really efficacious. They impose grievous and needless restraints on personal freedom; they fetter commerce and navigation; they abridge the demand for produce and manufactures; and thus, by making scant the means of life over wide and populous districts, they nourish discontent, increase all the sufferings attendant on poverty, and give rise to *inborn* diseases, far more spreading, and scarcely less severe, than those against which they are intended to act as barriers.

The basis, however, of a wise and beneficial system of quarantine laws,—of such a system as, while it affords all needful security against the introduction of contagious diseases, shall trespass no more than is absolutely unavoidable on the vital interests of trade and commerce,—can only be found in a collection of well ascertained facts respecting contagion. Of these it is

* See "the Philosophy of Domestic Economy," by Charles Sylvester, which contains a full account of Mr. Strutt's plans, as carried into effect at the Derbyshire General Infirmary, 1 vol. thin 4to. Published by Longman and Co., London, 1819.

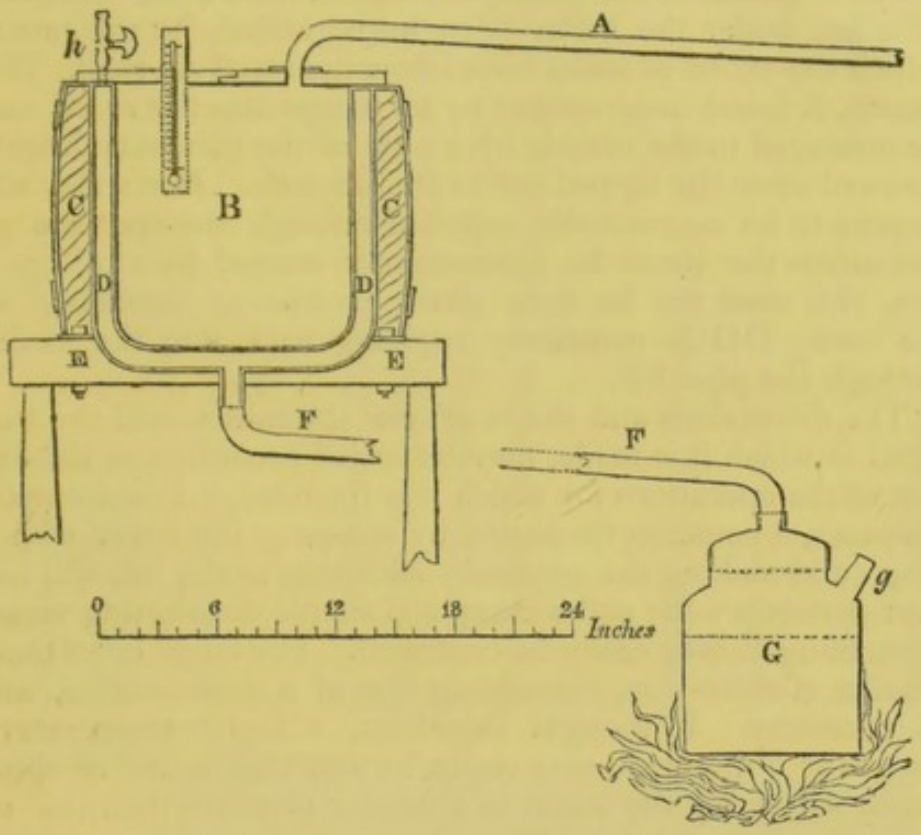
not

not beyond the truth to assert, that there is a lamentable deficiency. It has unfortunately happened, that the phænomena of contagion have generally been investigated, at times when the quarantine laws have been under the deliberation of Parliament; and this with a view to supply evidence, which, however honest and sincere, has been collected from observers, on both sides, who were under the influence of pre-conceived opinions. But it is not at such seasons, or in such a spirit, that so difficult and momentous an inquiry should be instituted. It must be begun, and pursued, in that dispassionate temper, which leaves the mind at liberty to examine phænomena with patience and accuracy; and to reason upon them with no other purpose, than that of deducing incontrovertible conclusions; —conclusions upon which, and upon which alone, *rules of practice*, of the greatest benefit to mankind, may be founded, as the final issue and reward of the investigation.

Description of the Apparatus.

The apparatus employed in the process of disinfection is so simple, that a representation of it can only be required by those who are not conversant with the application of steam as a source of heat. The object, in this instance, is to place articles of clothing, &c. which are intended to be disinfected, in a steady temperature, above 200° Fahrenheit, for any required length of time, without, however, allowing the steam to come into contact with the substances so exposed. This is effected by two vessels of copper, or of tinned iron, on the innermost of which the letter B stands in the sketch. The latter vessel is set within a larger one of similar shape, upon the edge of which it rests by a rim, which is united to the larger vessel by solder. There is, therefore, a cavity between the two vessels, shown by the letters DD, for containing the steam. The bottom of the outer vessel is a little dished or sloped downwards, and to the central part is soldered a short pipe for admitting steam and returning water; the space, on the centre of which the letter B is placed, is the *receptacle* for the articles, which are to be heated. To avoid the waste of heat through the sides of the outer vessel, it is packed all round, as shown at CC, with any non-conducting substance, such as hemp, bands of straw, or rolls of flannel. To prevent these from being displaced, they may be surrounded by barrel-staves secured by hoops of wood or metal. Over the top of the apparatus a wooden cover is applied, which being rabbeted along the middle, as shown by the sketch, admits either of one-half or the whole of the cover being removed at pleasure. From this cover, towards the right, a pipe A proceeds

ceeds, the only object of which is to carry into the flue of the chimney any infectious effluvia that may possibly escape undecomposed. The thermometer is introduced occasionally through a slit in the other half. The small air-cock *h*, which is removable at pleasure, passes through an aperture in the same half of the cover; and when open establishes a communication between the space DD and the atmosphere. The whole vessel rests on a table EE (the legs of which are represented



as if broken off), hollowed out to receive it. To this table the vessel is fastened by four small bolts, the extremities of two of which are shown by the sketch. To give a hold to the heads of these bolts, a *flanche* is soldered near the bottom of the outer vessel, which has also a corresponding *flanche* at the top, for the purpose of keeping the packing in its place.

The small boiler G has a movable lid, from the centre of which issues a pipe FF, five or six feet long, or any other convenient length, which slips over the pipe that descends from the steam-vessel. To bring the drawing into less space, this pipe is represented with a part broken off. The dimensions of every part of the apparatus are given by the scale, annexed to the sketch.

The vessel G is to be filled about two-thirds with water, which, to save time, may be nearly boiling at the outset.

Being

Being set over a fire, and the joints that require it having been made good by flour-paste spread on paper, the opening *g* is to be shut by a cork or plug, and the small air-cock opened, to allow the escape of the air confined in the space DD. Both halves of the cover being then put into their places, the thermometer is to be introduced through the slit. When it indicates upwards of 200°, that half of the cover from which the pipe A proceeds* is to be removed; the infected articles are to be placed in the receptacle, and the half-cover replaced. The fire under the boiler is to be regulated, by the rate at which the excess of steam issues from the small air-cock. This excess, if found inconvenient by its escape into the room, may be conveyed to the outside by a pipe of the necessary length, screwed upon the tapped end of the air-cock. Hot water will require to be occasionally supplied through the aperture *g*; but unless the steam be unnecessarily wasted by too large a fire, this need not be done often; as what is condensed in the cavity DD is constantly trickling back into the boiler through the pipe FF.

The dimensions and shape of the apparatus, and the material of which it is made, may be varied according to the extent of the operations for which it is intended. For domestic purposes, a common tea-kettle, by stopping the spout with a plug, and making the necessary additions to the lid, will answer perfectly well; and a cheap and simple disinfecting vessel resembling B may easily be contrived. For large operations a boiler of sheet-iron, resembling that of a steam-engine, will be necessary. If thought expedient, a higher temperature than 212° Fahrenheit may easily be obtained in the receptacle, by subjecting the steam to a greater pressure than that of the atmosphere; the apparatus being in that case provided with a proper safety-valve.

If heated air should be found adequate to the effect, it might be employed for ordinary articles, reserving the more costly vehicle, steam, for articles which are of great value, and which are easily injured.

* The pipe A will be found much more convenient if made in two parts, the part attached to the cover being not more than a foot long; its open end being made to slip *into* the longer part, as a few drops of moisture always escape.