bread supplied to it, without apparently being in the slightest degree influenced by the putrid diet. The same mouse had been previously subjected to a similar experiment with the putrid contents of the intestines of another patient, who died from some other disease, without suffering apparently any inconvenience. The result of these experiments I do not consider sufficient to refute the statements of the German physiological chemists; but perhaps it may be admitted that they tend to show that experiments bearing in such a striking manner on the essential character of the disease, require repetition before we can with certainty conclude that the intestinal fluids in cholera are possessed of contagious powers.

ROBERT DUNDAS THOMSON, M.D., F.R.S.

St. Thomas' Hospital,
March 1855.

No. XI.

Report on the Microscopical Examination of the Blood and Excretions of Cholera Patients. By Dr. Hassall.

THE outward and physical characters of the rice-water evacuations of cholera vary considerably in different samples and in different cases; they vary in colour, consistence, and composition; ordinarily they resemble thin gruel rather than rice water, being thicker and less white and transparent, and sometimes they are of a brown tinge. After being set aside for some time they usually let fall a deposit, the amount of which is subject to great variation, but generally it is considerable, forming in some cases as much as a fourth or a sixth of the entire bulk.

When submitted to examination with the microscope there are detected in most samples molecules and aggregations of molecules, innumerable mucous corpuscles, single and aggregated, of irregular size and form, and which are frequently imbedded in a mucous base, presenting sometimes a fibrous structure, and molecules and globules of oil; it is of these elements, and especially of the granular corpuscles and mucous base, that the deposit which subsides in most samples is principally composed.

In addition to the above, myriads of vibriones were detected in every drop of every sample of rice-water discharge hitherto subjected to examination. Of these vibriones many formed threads more or less twisted, while others were aggregated into masses, which under the microscope presented a dotted appearance.

But some of the specimens possessed characters very different from the above.

In one sample examined there were no granular or mucous corpuscles, or mucous base to be discovered, but in place of them a great number of globules of oil and innumerable minute acicular crystals, some of which were free, but mostly they were aggregated in bundles in the form of rosettes and dumb-bells. The vibriones were present as usual.

The same crystals occurred in another specimen in great numbers. In this case they were mostly single and but seldom aggregated, and there were no large globules of oil, although a good deal of oil was present in the form of molecules and small droplets.

In addition, numerous fragments of muscular fibre, cells of potato, a few starch corpuscles, and fragments of the husk of wheat, were not unfrequently detected in specimens of the rice-water discharge, and in cases in which food had not been partaken of for a considerable time.

The same acicular crystals were likewise seen in small numbers in two or three other samples, and in several prismatic crystals of triple phosphate.

In none of the samples were sporules or threads of any species of fungus present, or a peculiar body of any kind noticed other than the vibriones mentioned, and in none were well-formed cells of cylinder epithelium, that which coats the surface of the villi of the intestines, discovered.

Such is an enumeration of the different elements and constituents detected by means of the microscope in the specimens of rice-water discharge, about twenty-five in number, subjected to examination, and many of which were obtained from different cases. Fig. 26.

The presence of vibriones in the rice-water discharge being, so far as my experience goes, constant, it became of importance to determine the circumstances under which they make their appearance, and especially to ascertain whether they were present in the evacuations when first passed. In order to determine this point I made arrangements to obtain specimens as quickly as possible after being voided. I had a microscope ready for use placed in the Abernethy Ward of St. Bartholomew's Hospital, so that the discharge might be examined immediately that it was passed. In this way I succeeded in examining several samples within two hours of their being voided, and two others from separate cases immediately they were evacuated. In all of these the vibriones were present in large numbers. In one case I examined, in conjunction with Mr. Rainey, some of the rice-water discharge taken direct from the small intestines about twelve hours after death, and in this case also the vibriones equally abounded. In all cases the species was the same.

It thus appears that vibriones are constantly present in the rice-water discharge of cholera, and that they are developed in it during life, and while still retained in the small intestines.

From observations which have been elsewhere recorded* it appears that two of the circumstances necessary to the development of vibriones are a feebly acid, or more usually an alkaline, fluid and organic matter, especially animal, in a state of decomposition more or less advanced.

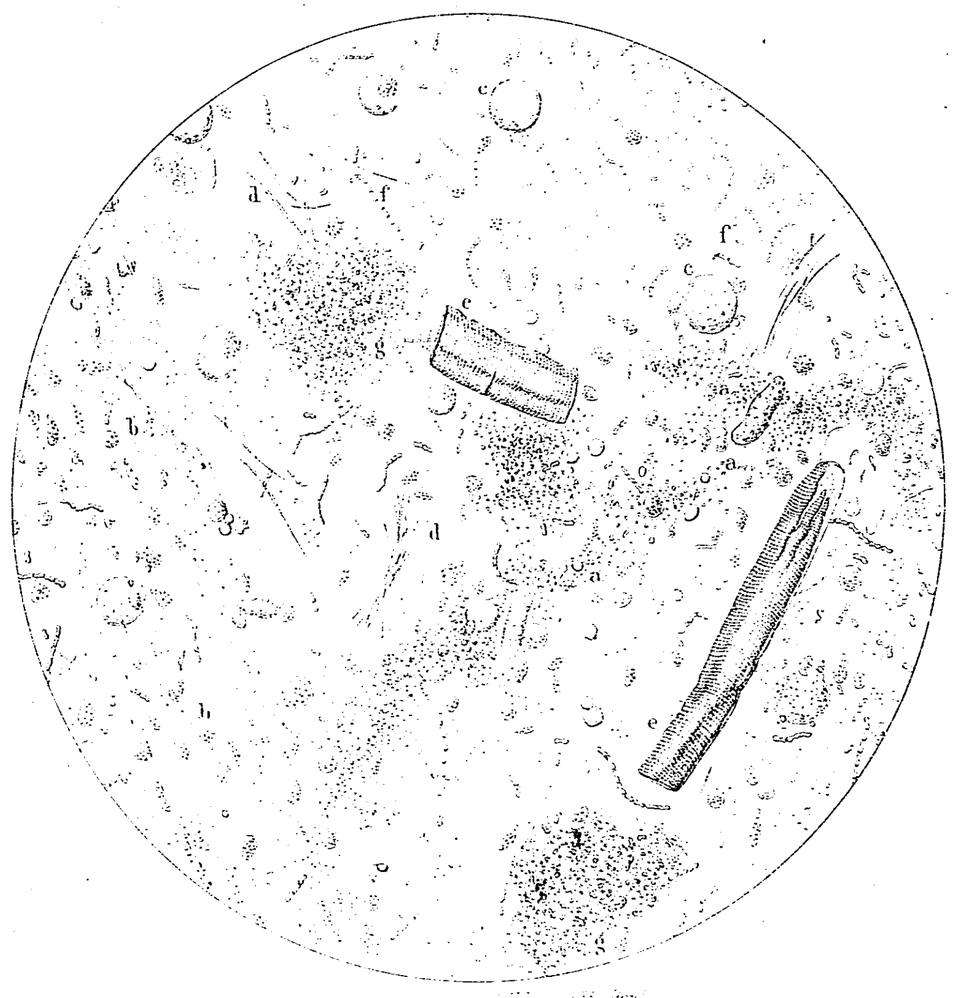
Now, in the rice-water discharge of cholera both of these conditions are fulfilled. In the first place it is always offensive, sometimes exceedingly so, resulting from decomposition; and in the second it is always, so far as my observations extend, highly alkaline.

We have next to inquire what is the origin or source of these vibriones, and what their relation to cholera?

With respect to the first point, there is no doubt but that there is more than one source for them, setting aside the idea of their spontaneous generation in decomposing organic fluids. It is possible that they may obtain entrance into the stomach and bowels by means of the atmosphere, and it is perfectly certain that they do frequently gain admission through some of the impure waters consumed, in which I have not unfrequently detected the presence of vibriones, sometimes in considerable numbers.

Once introduced into the alimentary canal, they are brought into relation with conditions highly favourable to their development and

* Proceedings of Royal Medical and Chirurgical Society.



aa *Molecules granules & granular Corpuscles single & aggregated*
bb *Shred of Mucus*
cc *Globules of Oil*
dd *Acicular Crystals*
ee *Fragments of Muscular Fibre*
ff *Vibriones*
gg *Masses of same*

propagation, both of which take place with almost inconceivable rapidity; thus they are brought into contact with abundance of organic matter, mostly in a fluid or greatly divided state, and more or less altered by decomposition, and the fluid in which this animal matter is contained is highly alkaline, and its temperature being raised many degrees above that of the external air also promotes greatly the development of the vibriones. Once admitted into the alimentary canal, it is not, therefore, surprising that they should be developed in inconceivable numbers, and with amazing rapidity.

I have made two or three examinations of healthy and natural fæcal evacuations at the time of their being passed, and in these I have detected the presence of comparatively a very small number of vibriones. It is most probable that the development of these in such cases takes place in the lower part of the intestinal canal, as it is there that in healthy digestion incipient decomposition first takes place, but further observations on this point, especially in cases of ordinary diarrhœa, are still required.

That they should not be present, or if present, only in small numbers, in healthy intestinal evacuations, is satisfactorily explained by the fact that the circumstances favourable to their development do not exist in the same degree as in cholera. The disposition to decomposition does not exist to the same extent, neither are the matters discharged equally alkaline.

Without, however, at all supposing that there is any essential or primary connexion between these vibriones and cholera, their occurrence in such vast numbers in the rice-water discharges of that disease is not without interest, and possibly is of importance; thus, their presence seems to indicate that the fluid thrown out into the intestinal canal in cholera, and especially into the small intestines, is in a state more than ordinarily prone to pass into decomposition, and that the fluid itself is more than usually alkaline. A condition of the intestinal discharges more than usually alkaline would assuredly act as a source of irritation to the mucous membrane of the intestines, as alkaline urine does to that of the bladder.

The existence of these vibriones in the evacuations may also possibly explain in some degree the success of sulphuric acid in checking the diarrhœa. Thus, that acid when freely administered destroys the conditions essential to the development of the vibriones, and so destroys the vibriones themselves. Thus, it checks the tendency to decomposition, and lessens or neutralizes the alkalinity of the fluid poured out by the intestines.

The mere presence of such a large amount of decomposing organic matter in the alimentary canal so high up as the small intestines, the principal seat of absorption of the chyle, must exert a seriously depressing influence upon the system.

The next point for consideration in relation to the rice-water evacuation of cholera is the occurrence in it of the acicular crystals noticed.

These crystals were present in large quantities in two only of the samples examined, but a few were detected in two or three other specimens. They therefore do not form a constant element of the rice-water discharge, but possibly the material or substance from

which they are formed may exist in all the samples, although not in the crystallized state. One of the specimens in which they were detected in great abundance was examined within two hours of its being passed.

These crystals bear a considerable resemblance in form, size, and arrangement, to those which are so often met with in connexion with decomposing oily and fatty matters, and they probably consist of some fatty acid. In the two cases in which they occurred in the greatest abundance no castor oil or oleaginous article of food had been given.

In connexion with the occurrence of fatty matter in the rice-water evacuations of cholera, the following particulars appear to be possessed of interest.

A few days since I received from Dr. Brown, of Hans Place, Chelsea, a bottle containing some rice-water discharge, on the surface of which there were floating some 16 or 17 masses of an intense verdigris green colour; some of these were of about the size and form a kidney bean, but others were smaller and rounder; they were of a soft waxy consistence, and on viewing them with the microscope it was ascertained that they were entirely composed of globules of oil; these globules were large, very soft, and easily made to alter their shape by the slightest pressure, and even by their own weight. The fluid in which these masses floated resembled the ordinary rice-water discharge; there were dispersed throughout it innumerable spherules of oil, having all the characters of those of which the green masses were formed, and from the breaking down of some of which masses these spherules of oil were derived. Around some of the globules, especially the free ones, a membrane precisely like that of ordinary fat vesicles was perceived. Lying loose amongst the oil globules, and in some cases formed apparently out of their investing membranes, were a few crystals, resembling those already described as occurring in certain of the specimens of rice-water evacuations examined; frequently the appearance of crystals on the largest globules was fallacious, and was produced by certain creases or folds in the membranous covering of the globules.

Wishing to obtain as much information as possible respecting these masses, I gave some of them to Dr. Letheby for chemical analysis, whose report concludes with the following remarks:

"It is manifest from the preceding, that the fatty masses consist chiefly of margarin and olein, with a portion of stearin, cholesterin, and bile. It is probable that the green colour is dependent on the last-named substance, though from the fugitive character of the tint I am disposed to think that it might have been owing to that peculiar kind of refraction which Professor Stokes has named *fluorescence*."

Most of the specimens of rice-water discharge after examination were set aside in my laboratory, and exposed to the air in open vessels, some of them for many days; a scum of vibriones formed on the surface of nearly all, and most of the samples became of a light pea green colour. Although thus exposed, and persons were constantly engaged in the laboratory, no ill effects resulted.

In one fatal case of cholera a portion of the mucous membrane of the duodenum was submitted to microscopical examination. Contrary

to what might have been anticipated, the villi were found to be coated with a well-formed layer of cylinder epithelium; this appears to show that the granular corpuscles contained in the rice-water evacuations proceed principally, if not entirely, from the mucous follicles. No alteration was detected in the villi themselves denuded of their epithelial covering.

Results of the Microscopical and Chemical Examination of Seventy-two Samples of the Urine of Cholera Patients.

As the details of the various observations made would be tedious, I have classified the principal results derived from the examination of the different urines separately in each case, as follows:

Thomas Richardson, St. Thomas' Hospital.

In all, twenty-nine samples of this urine were subjected to observation and examination, commencing from October 15th, this being the first urine passed after twenty-nine hours' suppression, and ending November 13th.

Albumen was ascertained to be present in fourteen samples, viz., in those passed from October 15th to October 28th inclusive, traces only being found in the urine passed on the last date.

Fibrinous casts of the renal tubules were detected in ten samples, from October 15th to November 4th. The casts discovered in the samples of October 27th were tinged with bile.

Oxalate of lime in dumb-bell crystals was also present, as well as a few octahedra of the same in three specimens, those of October 15th and 16th and November 4th.

Uric acid in crystals occurred in the sample of October 19th, and *urates* in those of October 15th and 16th.

Indigo was developed in eighteen samples, from October 19th to November 13th. The largest quantity found was in those of October 19th, 24th, and 27th, there being sufficient on these to form a scum of deep blue over the surface of the urine plainly visible to the naked eye. In some of the other specimens the indigo formed only a thin ring of blue round the edge of the fluid, while in others the quantity was less considerable, and required the aid of the microscope for its detection. The blue which had collected on the surface of the sample passed October 19th was removed, and the urine again left exposed; in a few days a second pellicle of the blue pigment had formed on the surface and around the edge of the vessel, describing a bright blue ring or circle.

Indigo was not detected in the samples passed on certain intermediate dates.

The sugar fungus was found in five of the specimens, in those passed October 15th, 16th, 19th, and November 3d and 4th.

Monads were contained in ten samples.

The *specific gravity* of the above samples of urine varied from 1004 to 1011, the average gravities being 1006, 1007, and 1009. The sp. gr. of three of the five urines which were found to contain sugar were as follows: October 19th, 1011; November 3d, 1007; November 4th, 1009.

The *reaction* of most of these urines was decidedly acid; in seven of the other samples the acidity was but feeble; while in those passed on October 26th and 27th, and November 1st, 2d, 4th, and 6th, it was neutral.

William Stevens, St. Thomas' Hospital.

Fifteen samples of the urine in this case were received and examined, viz., from October 28th to November 13th.

Albumen was found in six samples, those from October 28th to November 4th, after which it disappeared.

Fibrinous casts, none were seen in any of the above samples.

Oxalate of lime in octahedral crystals was seen in two specimens in large amount, in that of November 8th, and in smaller quantity in that of November 10th. The sugar fungus being present in one, if not both, of these specimens.

Uric acid in crystals, single and aggregated into stellæ, were present in two of the urines, those of October 28th and 31st, and urates in globules or spherules in those of November 4th and 9th.

Indigo was developed in seven of the specimens; in those passed from October 28th to November 13th; in six of the urines the indigo formed a blue ring round the edge of the vessel, in the others the microscope was necessary for its detection.

Indigo was not found in the samples passed on certain intermediate dates.

The sugar fungus was developed in seven of the urines, viz., from October 28th to November 8th.

Monads abounded in seven samples.

The *specific gravity* ranged from 1009 to 1019, but was generally 1011. The sp. gr. of the urines, in which sugar was found, was as follows: 1010, 1011, 1009, 1012.

The *reactions* of the samples were as follow:—Ten were decidedly acid, two feebly acid, and three were neutral.

James Madden, St. Thomas' Hospital.

Nine samples of this urine altogether were examined, the first being that of October 19th, which was passed after twenty-four hours' suppression; and the last, October 27th.

Albumen was present in seven specimens, from October 19th to 27th, and was no doubt also present on the intermediate and some of the following days.

Fibrinous casts were seen in three of the urines—Oct. 19th, 22d, and 26th, and were also, no doubt, for the most part present on the intermediate days.

Urates, in the form of dumb-bell crystals, were present in two samples, October 19th and 23d; in the first of these some of the urate was deposited in the renal casts.

Indigo appeared in eight samples, from October 19th to 27th. The largest quantity was in those of October 19th and 20th, in which it formed a perfect scum over the surface; a good deal of the pigment was also deposited with the sediment. In the remaining specimens the indigo formed a ring of blue round the edge of the fluid, plainly visible to the naked eye. The indigo of two of these samples was collected, and after exposure, the urine deposited a further quantity of indigo.

The sugar fungus was not observed in any of these samples, nor any dumb-bell crystals of oxalate of lime.

The *specific gravity* ranged from 1010 to 1014, the usual gravity being 1011 and 1012.

The *reaction* of these urines was more or less acid, with the exception of those of October 25th and 26th, when it was neutral.

This patient quitted the hospital, October 28th, apparently well, although, as we have seen, the urine had not entirely ceased to be albuminous.

Robert Quarrell, St. Thomas' Hospital.

Two samples of this urine were examined, passed October 12th.

Albumen was found in large quantity in both specimens.

Fibrinous casts, in great numbers, also occurred in both.

Dumb-bell oxalate of lime, in fine large crystals, was found in the second sample.

Uric acid occurred in both, and was very abundant in the second specimen, while *urates* were found only in the first sample.

Indigo became developed in both the urines, more particularly in the second; but at first, in neither case was the quantity large, the microscope being required for its detection. In the second sample the indigo was deposited partly in the thallus both of the sugar fungus and of penicilium glaucum. Although at first no blue visible to the naked eye was developed on the surface of either of the urines, yet after the removal of the scum of fungus which had formed over the surface of the second sample, and on well agitating the urine, in the course of a few days a dense blue scum became developed all over it. The blue colour was probably not developed at first, in consequence of the contact of the air with the surface of the urine being impeded by the pellicle of fungus which had grown over it.

The *sugar fungus*, in perfect fructification, appeared in the second sample.

The *specific gravity* of the sample containing the sugar was 1018.

Reaction of both specimens very acid.

James Palmer, St. Thomas' Hospital.

One sample only of this urine was examined, which was passed October 3d.

Albumen was detected in this urine.

Renal casts, a few only were seen.

Oxalate of lime in dumb-bells occurred, also a few large octohedral crystals of the same salt.

Indigo appeared in sufficient quantity to form a thin blue scum over the surface; this was collected and the urine again exposed, when after some days a thin ring of pale blue formed round the edge of the fluid.

Specific gravity, 1017. *Reaction,* decidedly acid.

JOHN BRANDON, St. Thomas' Hospital.

Only one sample of urine in this case was examined, this being passed October 5th.

Albuminous, but no *renal casts* were seen, nor was any *indigo* deposited. In the sediment there was found a few large sporules, which had more the appearance of those of the sugar fungus than of penicilium glaucum, but yet were scarcely so large as those of the yeast plant.

Uric acid was rather abundant.

The quantity of this urine obtained was too small to allow of its specific gravity being taken. *Reaction,* decidedly acid.

From St. Thomas' Hospital.

This specimen of urine was passed October 5th.

Albumen was present in small quantity only.

Oxalate of lime in dumb-bells was deposited in very large amount.

Urates were likewise contained in this urine.

The *sugar fungus* was met with in small quantity.

Specific gravity 1014. *Reaction,* decidedly acid.

From St. Thomas' Hospital.

This sample of urine was passed September 29th.

Albumen was present in small amount.

Fibrinous casts, only a few fragments detected.

Neither *Oxalate of lime, sugar fungus,* or *indigo,* were developed in this instance.

Urates of a pink colour were deposited in considerable amount.

Specific gravity of the urine, 1024. *Reaction* very acid.

From St. Thomas' Hospital.

One sample only of this urine was obtained.

Albumen was found in large quantity.

Renal casts in large numbers were likewise present.

Oxalate of lime, in dumb-bell crystals, occurred in considerable quantity.

Indigo appeared on the surface, forming a dense reddish blue scum all over, which was collected; some also was deposited at the bottom of the glass. After the removal of the pellicle first formed, and further exposure of the urine a second thin blue scum was developed on the surface.

The *specific gravity* of the urine was 1016.

The *reaction,* as evidenced by the growth of fungus, was acid.

From St. Thomas' Hospital.

The sample of urine examined in this case was passed October 7th.

Albumen occurred in this urine.

Uric acid in tablets, and also in long straight threads, made up of aggregations of small crystals of the same form, occurred in large quantity. It was particularly observed that the threads of crystals were formed independent of fibres or nuclei.

Indigo was formed in small quantity, which was visible to the naked eye, and many pieces and fragments of it were discovered by means of the microscope.

Bile in small quantity was also present in this specimen, as shown by the manner in which the epithelial cells were coloured or stained with that substance.

Monads occurred in large numbers.

The *specific gravity* was 1010. *Reaction* decidedly acid.

From St. Thomas' Hospital.

This sample of urine was passed October 5th.

Albumen was found in large quantity.

Renal casts, a great number were seen.

Oxalate of lime in dumb-bells, and octohedra a good deal.

Indigo, a few fragments only discovered with the microscope; some of the indigo had also become deposited in the threads of penicilium glaucum.

The *sugar fungus* in perfect fructification was rather abundant.

Specific gravity, 1017. *Reaction* very acid.

CHARLES BARBER.

The specimen of this urine examined was passed October 3d.

Albumen was present in this sample in large quantity.

Renal casts were discovered also, but not many.

Oxalate of lime in dumb-bells occurred, but the number of crystals was but small.

A small quantity of the *sugar fungus* was likewise developed.

Indigo was deposited in sufficient amount to form a blue scum over the whole surface of the urine; this was removed, and the urine again left exposed to the air; in a few days a second deposit of blue took place, forming a thin ring round the edge of the vessel; a great many fragments of the same were likewise discovered with the microscope.

The *specific gravity* was 1012. *Reaction* very acid.

THOMAS BATES.

This sample of urine was passed forty-eight hours after collapse.

Albumen was present in rather large amount.

Renal casts abounded in this specimen.

Oxalate of lime, chiefly in dumb-bells, was deposited in large quantity, some of the crystals being formed in the casts of the renal tubules.

Uric acid was present in considerable amount, as also much urate; a good deal of the latter was deposited in the fibrinous casts, and in the epethelial scales which were contained in the urine. Fig. 27.

Indigo did not appear in this urine.

Specific gravity, 1018. *Reaction*, acid.

From Charing Cross Hospital.

The first sample was passed October 4th.

Albumen was found in rather large quantity.

Renal casts were seen in great numbers.

Oxalate of lime in dumb-bells occurred very abundantly, as well as many octohedral crystals of the same.

Urates also were met with, some of which were deposited in the renal casts.

Indigo appeared, forming a reddish blue scum over the whole surface.

Patrick Reilly, St. Bartholomew's Hospital.

Two samples of this urine were examined, being the first two passed on the subsidence of collapse.

Albumen was present in both urines.

Renal casts also in both, but not in large number.

Uric acid was found in the first urine passed.

Oxalate of lime, in the form of octohedral crystals, was discovered in the second sample.

The *sugar fungus* likewise occurred in the second sample.

Indigo was developed in both samples, but in largest amount in that first passed, in which it formed a decided blue scum all over the surface. In the second specimen the indigo at first only formed a well-defined border round the edge of the glass, but after agitation, in the course of a few days a slaty-blue scum appeared over the whole surface of the liquid.

Monads in large numbers appeared in both urines.

The *specific gravity* of the two samples was 1014 and 1015.

The *reaction* of both decidedly acid.

——— Fitzgerald, St. Bartholomew's Hospital.

Two samples of the urine in this case were examined.

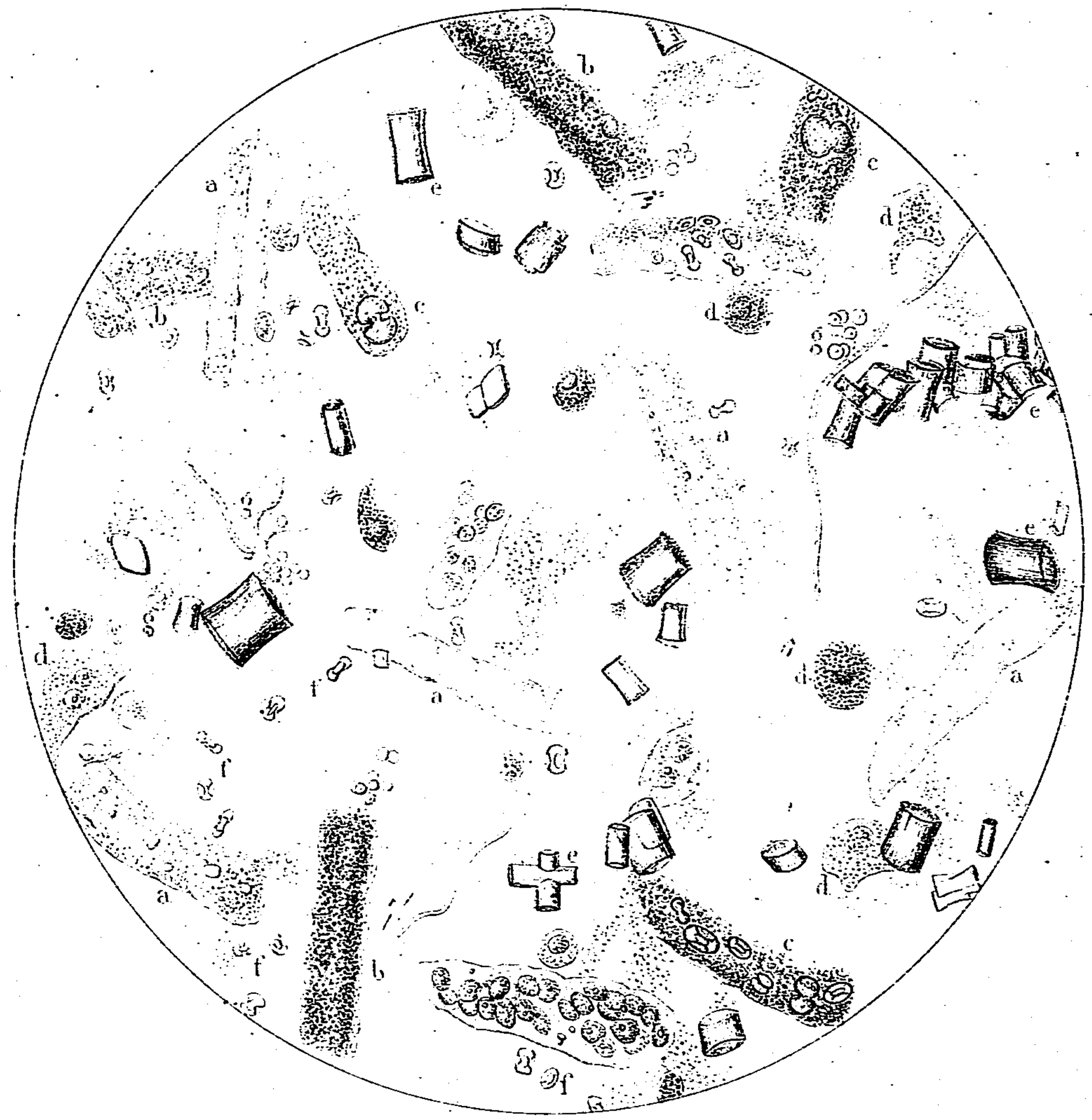
Albumen was found in both the specimens.

Renal casts occurred in both, and in very large numbers in that passed October 4th.

Oxalate of lime in dumb-bells was deposited in the sample of October 4th.

Uric acid in tubular crystals was found in both specimens, together with much *urate*.

Indigo was not formed in either of the urines.



aa *Fibrinous casts of the Renal tubules*
bb. *Casts coloured with urate*
cc. *Casts with Dumb bell Oxalate of lime*
dd *Epithelial scales coloured with urate*
ee. *Crystals of Uric Acid.*
ff *Dumb bells crystals of Oxalate of lime*
gg *Sporules & threads of Penicilium glaucum.*

The *sugar fungus* was seen in only one of the samples, viz., that passed October 5th.

The *specific gravity* of the urines was 1017 and 1018.

The *reaction* of both decidedly acid.

From St. Bartholomew's Hospital.

A drachm only of each of the two following samples of urine was forwarded for examination:

Albumen was detected in both samples.

Fibrinous casts of the renal tubules were likewise present in both the urines.

Oxalate of lime in dumb-bell crystals occurred in the two specimens.

The *sugar fungus* likewise became developed in both and attained its perfect fructification, particularly in the second sample, the fungus forming a perfect scum over the entire surface of the urine as it was exposed to the air in a test-tube.

Ellen Godfrey.

This was said to be the first urine passed on recovery from the attack.

Albumen was found in large quantity.

Renal casts were not observed.

Dumb-bell crystals of *oxalate of lime* occurred in rather large number.

Uric acid in crystals a few, as well as much granular *urate*.

Indigo appeared in small amount only, the microscope being requisite for its discovery. Some of the blue pigment was deposited in the epithelial scales contained in the urine.

The quantity of urine sent was too small to allow of its *specific gravity* being ascertained. Its *reaction* was neutral.

It is obvious that there is much in the above results of the examination of the urine of cholera of interest and importance.

The first particular of importance relates to the albuminous condition of the urine. That the urine in cholera is frequently albuminous has long been known; but it now appears that it is almost constantly so, and that this condition of the urine persists for a considerable period after the attack has passed away, facts particularly worthy of notice. I have not met with a single undoubted instance of the absence of albumen from the early samples of urine passed in cases of cholera; while in one or two of the cases here recorded the patients were actually dismissed from the hospital as well, and apparently they were so, although the urine still continued to be albuminous.

The next particular for consideration is the occurrence in the urine of fibrinous casts of the renal tubules. These are almost invariably present in the early samples of urine passed on recovery from the attack of cholera, and sometimes they are to be detected for

a considerable time, occasionally not altogether disappearing until after the urine has ceased to be distinctly albuminous. The urine of cholera presents the best and most perfect examples of this form of renal casts which I have ever met with, the casts being so well defined, abundant, and often containing imbedded in their substance different forms of urinary deposits, as urates, dumb-bell crystals of oxalate of lime, &c. Fig. 27.

Not unfrequently the casts are shaded of a dark colour, in consequence of the quantity of urate imbedded in them. Very commonly, also, dumb-bell crystals of oxalate of lime are met with similarly imbedded, a fact which shows that this salt crystallizes in these cases immediately after the urine is secreted, and while within the renal tubules. Nearly the whole of these particulars are shown in the figure above referred to.

Another important particular is the occurrence of deposits in the early samples of cholera urine voided. These are noticed especially in the first two or three samples passed. They consist of uric acid, urates, and particularly dumb-bell crystals of oxalate of lime.

That the oxalate of lime should be deposited so commonly in the form of dumb-bells, and not in the usual octohedral crystals, is a remarkable fact, and one which seems to show that a very essential distinction exists between these two crystalline forms of what is usually considered to be the same salt.

After the urines have been kept for some days numerous changes are observed to occur in them. The quantity of deposits, especially those of uric acid, urates, and oxalate of lime, often becomes increased, the urines become turbid, alter in colour, fungi are gradually developed in them, and lastly, in many instances, a scum or pellicle of pigment of a blue colour, more or less marked, forms upon their surface.

The formation of a blue pigmentary substance on the urine in cases of cholera has been before noticed, and principally by Heller. That observer bestowed upon it the name of Uroglaucin, and considered it to be a modification of urine pigment.

I have elsewhere shown that indigo is of frequent occurrence in human urine,* and in the communication referred to I advanced certain reasons to prove that the uroglaucin of Heller is really indigo. Of this fact no doubt now whatever remains, as I have succeeded in obtaining from several of the samples of blue pigment procured from cholera urines all the reactions so well marked which characterize indigo. This may be considered to be an important result, and I am now fully convinced that only one blue pigmentary substance is ever formed naturally in the urine, and that this is in all cases indigo; the uroglaucin of Heller and the cyanourin of Scherer being merely impure states or conditions of indigo.

It will be observed, that the yeast-plant or sugar fungus was met with in different samples of the urine in nearly every case. This is another very interesting fact in connexion with the urine of cholera.

* "On the frequent occurrence of indigo in human urine, and on its chemical, physiological, and pathological relations."—*Transactions of the Royal Society*, 1854, p. 297.

Of the value of this fungoid test for sugar I have elsewhere adduced evidence,* but additional proof is now furnished of its great utility. The yeast-plant was met with in different stages of growth in at least fourteen samples, while evidences of its existence were observed in several other specimens. The specific gravity of the urines in which it was actually detected ranged from 1007 to 1018, the average gravities being 1009 and 1011; by no other single and direct test could sugar, when present in urine in amount comparatively so small, be detected. In all probability sugar was present in some of the other samples of urine, in which the sugar fungus had not become developed. Some of these specimens were either neutral or alkaline, and as it is essential for the growth of this fungus that they should have an acid reaction, the fungus therefore did not make its appearance in these samples.

No organic production was present in any of the urines when first passed, neither was any subsequently developed in them which could be supposed to be associated in any way with cholera.

Report stating the Results of the Microscopical Examination of numerous Specimens of Blood obtained from the Bodies of Persons who had died of Cholera.

In all, eighteen specimens of blood were subjected to microscopical observation.

These specimens were in all cases examined a few hours after death, and in some instances almost immediately after dissolution.

The results of the observations made may be thus briefly stated:—

First,—That in none of the specimens were any organic productions present, animalculæ or fungi, either living or dead.

Second,—That in those specimens which were examined very shortly after death, the blood presented its usual structural characters and peculiarities. The red and white corpuscles were of the usual form and size, and presented their ordinary appearances. Occasionally, the red corpuscles were seen to be aggregated into the well-known piles, or rolls, while the white corpuscles were sometimes free and sometimes aggregated, and entangled in meshes of fibrin. This last appearance was presented when the blood had become coagulated, and was attributable to the separation of the fibrin and white corpuscles from the red corpuscles. The same separation occurs in blood after death from other causes than cholera.

Third,—That in some of those specimens of blood which were not examined until some hours after death, changes were observed to have taken place in both the red and white corpuscles. The red corpuscles had become smaller, of unequal size, more globular, and some of them appeared as though they had been in some degree melted down and

* "On the development of torulæ in the urine, and on the relation of these fungi to albuminous and saccharine urine."—*Medico-chirurgical Transactions*, vol. xxxvi. 1853.

dissolved away. The white corpuscles, at the same time, were not so uniform in size, and were less granular than natural, and there was frequently visible in them one or two shining droplets of fatty matter, a considerable number of free oil globules and a few fibrinous granules were likewise seen floating in the serum. These changes in the condition of the red and white corpuscles were entirely the result of incipient decomposition, and they were not observed in the very recent specimens of the blood, with the exception of a few molecules, and an occasional spherule of oily matter suspended in the serum.

Of the specimens of blood examined, some were obtained from the median cephalic vein, others from the larger internal blood vessels, and some from the cavities of the heart itself. Fibrinous clots or coagula were not unfrequently met with in the latter situation. These exhibited under the microscope all the usual characters of ordinary fibrinous clots, and consisted of fibrillæ of fibrin intermixed with granular matter and the white corpuscles of the blood.

The general result or conclusion to be deduced from these examinations is, that the blood, in cases of death from cholera, does not present any peculiarities discoverable by means of the microscope, its structure being uninjured, and it being entirely free from parasitic developments of every kind.

These observations appear sufficient to disprove two theories which have been entertained with respect to the condition of the blood as a cause of cholera. Thus it has been alleged that the symptoms of cholera were referable to a disintegration or breaking down of the blood corpuscles, and this is one of the theories; while the other theory supposes that cholera arises from the presence of some parasitic production developed in the blood itself, either an animalcule or a fungus.

It is of consequence that these theories, inasmuch as they are incorrect, should be disproved, since the treatment of cholera has not unfrequently been based upon the assumption that one or other of the theories referred to was founded on fact. In proof of this remark, the circumstance of the treatment of cholera by sulphur with the view of destroying any fungus or animalcule which might be present in the blood, may be adduced.

Report stating the Results of the Microscopical Examination of the Skin and Clothes of Cholera Patients.

So many cases having been reported from time to time of nurses who had been engaged in washing the clothes of cholera-patients becoming themselves the subjects of cholera, it was of importance to determine whether the presence of any body or substance could be discovered in the clothes worn during cholera which could explain the communication of the disease.

With this view the following examinations were made:

Portions of the epidermis or skin of six persons who had died of cholera were submitted to the microscope, as well as twelve pieces of

the clothes worn by cholera-patients at the time of decease; some of these being selected in consequence of their being stained with the rice-water evacuations.

Nothing of importance was discovered from the examination of the six portions of epidermis, neither animalcules as vibriones, or sporules or threads of fungi were present in any case.

The pieces of clothes were carefully washed in a little distilled water, and the water itself, as well as any sediment which subsided from it after it had stood for some time, were examined microscopically.

In some cases no solid matter of any kind was to be detected. In other instances vibriones abounded, and were alive and in active motion. The presence of vibriones was sufficiently explained by the fact, that the portions of clothes in these cases were stained with the rice-water discharge, which I have shown in a former report invariably swarms with living vibriones.

In two instances, (and particularly in one case,) in addition to the vibriones, sporules, some of which were germinating, of a species of fungus, were observed. Lastly, in some instances, epithelial scales, derived from the breaking down of the epidermis, were noticed, as also fragments of muscular fibre and vegetable tissue, starchy matter, corpuscles of wheat, together with bright blue particles, probably indigo. The starch and blue discovered was no doubt a portion of that used in the starching and blueing of the clothes examined, while the fragments of striped muscular fibre proceeded from the remnants of food contained in the rice-water discharge.

The only organic productions met with in the examination of the several pieces of linen to which any degree of suspicion is attached are the vibriones, upon which I have already remarked in the report containing the results of observations on the rice-water evacuations of cholera.

If these vibriones possess any influence in the production of cholera, or if the rice-water discharges contain any substance or principle capable of producing that disease, we can readily understand how the washing of the clothes might, in some cases, give rise to cholera in those engaged in washing them.

Report embracing certain Facts relating to the Diffusion of Animalcules and Fungi through the Medium of the Atmosphere, with Remarks concerning the Relation of such Diffusion with the Origin and Propagation of Cholera.

The reproduction of all the smaller and parasitical species of fungi is aerial; that is, they are propagated in contact with the air, and the germs or sporules are so exceedingly small, and are of such extreme lightness, that they are readily and rapidly diffused throughout the atmosphere on the slightest agitation or disturbance; the

atmosphere constitutes, in fact, the natural and ordinary means by which the sporules of this class of productions are diffused, and the propagation of the species ensured.

In the mere fact of the presence in the atmosphere of the sporules of different fungi there is nothing very remarkable, and in establishing the fact of such presence no connexion whatever is proved to exist between these fungi and cholera; indeed, the direct results of all the observations which have been made by means of the microscope into the condition of the solids and fluids of the body in cholera is wholly opposed to the notion that the development of fungi has anything to do with the disease.

It is not only sporules of fungi which are conveyed about in the atmosphere, but many other bodies of great minuteness and trifling weight, as for example, fibres of wool, the starch corpuscles of wheat and other plants; and so commonly are these contained in the atmosphere, that if any fluid be exposed to it for two or three days, these substances will very frequently be found in it on examination with the microscope.

From the fact that the sporules of fungi have been obtained from the emanations of sewers it has been concluded that these sporules were generated in the organic matters contained in them, and that they afterwards became liberated and set free into the air This is, no doubt, the case in some instances; but what I now desire to point out is, that the sporules of fungi thoroughly immersed in fluid cannot be conveyed into the atmosphere by the mere evaporation of the fluid holding them; thus, when the contents of the sewer are fluid and in motion, no diffusion of the sporules can take place; should any sporules, however, float on the surface of the liquid, a few of these might become diffused in the air, carried up by the vapour resulting from evaporation. The accuracy of this statement was proved as follows:—

A sample of urine containing myriads of sporules of the well-known fungus Penicilium glaucum was subjected to slow evaporation or distillation. The urine before distillation was deeply coloured and turbid from the quantity of fungus present, while the distilled liquid was as clear and as bright as water; and on examination of it with the microscope a very few sporules of the fungus were met with only after careful scrutiny. It was apparent to the eye alone that the great bulk of the sporules had been left behind. The very few which passed over were those which rested only on the surface of the urine, and which had not been fairly immersed in it.

The sporules of some species of fungi at a certain stage of their growth repel water and other fluids, so that although they may rest upon it they do not imbibe it, and are really aeriel, resting only on the surface.

We will next bestow a few observations upon vibriones.

First. Vibriones are developed and are to be found in nearly all animal and vegetable infusions which are not too acid (including impure water) at all seasons, and are not peculiar to a period of cholera. This one fact is in itself almost sufficient to prove that there

is no very close or essential connexion between vibriones and cholera. Nevertheless, the invariable presence of vibriones in the rice-water discharges of cholera, even while retained in the system, occasions considerable interest to be attached to these animalcules in relation to cholera. Although not the cause, they may still possibly possess some influence in explaining and aggravating the symptoms.

Next, as to the diffusion of vibriones through the medium of the atmosphere.

Vibriones are true aquatic productions, unlike fungi, which are for the most part aerial, fluids being the media in which, as far as I am aware, they are always developed, and to which they are usually confined; neither can they escape from those fluids and become carried into the atmosphere through the evaporation of the liquids in which they are present. Their incapability of being conveyed into the atmosphere in this way was shown by carefully distilling at a low temperature a portion of rice-water discharge which absolutely teemed with vibriones, and which was opake from the numbers present in it. The fluid distilled off was as clear and transparent as water, and no vibriones were discovered in it on the strictest scrutiny with the microscope; it follows, therefore, that if vibriones are really ever present in the atmosphere they are actually developed in it, and since they require moisture for their development, it must be in some humid condition of the atmosphere that they are thus generated.

Further, the presence of vibriones in the atmosphere implies also the presence of some nitrogenized substance capable of affording nutriment for their support.

It is, therefore, extremely desirable that the fact should be ascertained beyond the possibility of dispute whether vibriones ever float freely in the atmosphere, and, if so, whether their presence is confined to the period of the prevalence of cholera.

Vibriones are so abundantly diffused throughout a great variety of fluids, and they are generated with such extreme rapidity and in such incalculable numbers, that the greatest care is requisite in making observations of this nature.

I will now state the results of an experiment made for the purpose of determining whether anything could be detected in the breath of persons attacked with cholera.

With this view a Wolfe's apparatus was carefully prepared and charged with recently distilled water. Into this several patients labouring under cholera were made to breathe repeatedly for two or three days, at the end of which time the water was observed to be slightly dulled, and in it, after it had been allowed to stand at rest in a conical glass for some hours, numerous sporules of fungi and vibriones were seen, (the vibriones for the most part being developed around fibres of cotton, of which many were present,) a few monads and starch corpuscles of wheat.

On subjecting another portion of the same distilled water, and which had not been previously used in any way, to examination, sporules of the same fungus, and the same species of vibrio and monad were met with, although not in nearly such large numbers as in the water which had been breathed through by cholera patients:

fibres of cotton were also present, as well as starch corpuscles, but the number of these was likewise less.

No production, therefore, was present in the water through which several patients suffering from cholera had been made to respire repeatedly for a period of three days, which was not originally contained in the water used for the experiment. The only apparent effect of the respiration was to hasten and increase the development of the organic matters which were at first contained in the water.

One other experiment, which was made with the hope of throwing further light upon the subject, may here be related. Some water obtained from the artesian well in Piccadilly was submitted to distillation in vessels which had previously been prepared for the purpose, and which had been well washed with concentrated sulphuric acid, to destroy any trace of organic impurity which might accidentally have been present.

With the distilled water thus obtained, which was of very unusual purity, a Wolfe's apparatus, cleansed with the same precautions, was charged. Into this, I myself breathed from time to time, for the space of three days; on the second day the water was observed to have become somewhat dull, and on the third day it was opalescent; examined with the microscope, it was found to abound in large and active animalcules, apparently belonging to the genus Paramesium; no sporules of fungi or vibriones were noticed.

The presence of these animalcules in such large numbers can only be accounted for by supposing that a portion of saliva containing animal matter had made its way, together with the air, down the glass tube which passed into the water, and that this had formed the material or pabulum out of which the animalcules had become developed; but from what source the germs of the animalcules proceeded it is impossible to state.

The above observations on the conveyance of organic productions by means of the atmosphere in connexion with cholera are obviously very incomplete, but at the same time they may furnish some few hints for conducting at a future period similar experiments and observations on a more extended scale.

The general result of these observations, so far as they go, is to prove that the breath of patients labouring under cholera does not contain any organic production which can account for either the origin or propagation of cholera.

Concluding Observations.

The microscopical investigations instituted by me have embraced the Rice-water discharges of Cholera, the Blood, the Urine, the Epidermis or Skin, the Clothes of cholera patients, as well as the Water drank and the Air respired.

The one great result of these investigations is to show that neither in the blood or urine, or on the skin or clothes, or in the water drank, or in the air respired, are any organic productions, either animalculæ or fungi, present, to which the origin or propagation of cholera could be attributed.

The only fluid examined which was found uniformly to contain living organic productions was the rice-water discharge, which even while enclosed in the small intestines swarmed with vibriones.

The presence of these vibriones exhibits at least a remarkable proneness of the contents of the small intestines to undergo rapid decomposition.

In addition to the fluids and articles enumerated above, submitted to microscopical observation, I should mention that I examined portions of the livers and kidneys of two persons who had died of cholera, the mucous membrane of the bronchial tubes, the bile, and the contents of the bladder each in one case. The results were as follow:

One of the portions of liver was light-coloured and fatty-looking, while the other was red and dark-coloured; a few oil globules were found in some of the hepatic cells in both cases, but in larger proportion in the light-coloured piece than in the other; but neither of the livers could be said to be in a state of marked fatty degeneration, and by far the greater number of the secreting cells of these livers were in a state of integrity.

The gall-bladder of one of the livers was half filled with bile of a deep green colour, and having the consistence of treacle; this examined under the microscope was seen to abound in plates of cholesterine.

The microscopical examination of the kidneys did not furnish any particular result.

The epithelium contained in the mucus of the bronchial tubes was in a state of apparent integrity, but the fluid part of the mucus abounded in vibriones; the presence of these was, no doubt, due to incipient decomposition, although this decomposition was not appreciable either by the appearance presented by the mucous membrane or by its smell. There were also observed a considerable number of oil globules of all sizes, and large round corpuscular-looking bodies, perfectly free from granulation, and resembling closely the vesicular corpuscles of the white substance of the brain.

The bladder examined was exceedingly small and contracted, and on opening it there was present in it about a dessert-spoonful of a yellow, cream-like, and purulent-looking substance; this viewed under the microscope was found to consist chiefly of mucus and scales of vesical epithelium, no vibriones being present; their absence was sufficiently explained by the strong acid reaction exhibited by the mucus.

Arthur Hill Hassall, M.D.

Bennett Street, 22d January 1855.
