A microscopical examination of certain waters submitted to Jabez Hogg / and a chemical analysis by Dugald Campbell ; with introductory notes by Samuel Collett Homersham.

(32.)

A

MICROSCOPICAL EXAMINATION

OF

CERTAIN WATERS

SUBMITTED TO

JABEZ HOGG,

Surgeon to the Royal Westminster Ophthalmic Hospital; President of the Medical Microscopical Society; Fellow of the Royal Microscopical Society, &c.; Author of a work "On the Microscope," "On the Ophthalmoscope," "Parasitic Diseases of the Skin," &c.

AND A

CHEMICAL ANALYSIS

BY

DUGALD CAMPBELL,

Analytical Chemist to the Brompton Hospital.

WITH

INTRODUCTORY NOTES BY SAMUEL COLLETT HOMERSHAM,

Member of the Institution of Civil Engineers, London.

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PREFACE.

A Water Company supplying a considerable town in Yorkshire from the river flowing through it, the water being drawn at a point two miles below the town, during the last Session applied to Parliament for powers to substitute for the river water, mixed upland stream, and flood water, impounded together and stored in an elevated artificial lake.

The application was opposed before a Committee of the House of Lords, to whom the Bill was referred, by several parties, on various independent grounds, supported by evidence to prove that an adequate quantity, at a less charge, and of a better quality, could be obtained and supplied from an enormous natural store of subterranean water contained in the new red-sandstone geological formation, which crops out at the surface of the ground thirteen miles to the east of the town.

The results of a microscopical investigation relating to the respective characters of the stream and of the subterranean water, although carefully made for the purpose, were not brought to the notice of the Committee; nevertheless, the powers sought by the Bill were rejected.

In my opinion, the microscopical results have a scientific interest beyond the purpose they were intended to serve, illustrating as they do an important difference between the respective characters and wholesomeness of two classes of water at present not widely enough understood; for this reason I have recorded them in the following pages, accompanied by a few short introductory and explanatory notes.

SAMUEL COLLETT HOMERSHAM.

19, Buckingham-street, Adelphi, London, W.C.,
August 26th, 1874.

INTRODUCTORY.

Before fixing upon a source for the supply of water to a population, a microscopical examination of the water by a skilled medical practitioner, well acquainted with the forms, names, and habits of the minute organisms (vegetable and animal) that pervade most impure waters, and with a knowledge of the influence these exercise on public health, is as necessary to enable us to form a proper estimate of the fitness of the source, as an examination made by an analytical chemist.

Unfortunately, the necessity for a microscopical examination is not generally understood, and therefore it is not so constantly made as it should be.

For instance, the Commissioners appointed by Her Majesty on the 24th of December, 1866, for the purpose of inquiring into the means of obtaining additional supplies of unpolluted and wholesome water for the metropolis and other large towns, in their report, dated June, 1869, after an investigation carried on during a period of two and a-half years, make no allusion whatever to the character of different waters as revealed by the microscope.

With the sanction of the Lords of Her Majesty's Treasury, the Commissioners, as they inform us, caused numerous samples of waters to be collected for examination under their own direction. To enable them to report as to the respective qualities, they had the waters submitted to elaborate chemical analyses. Strange to say, however, although the Commissioners in their report state, towards the end of paragraph 194, "with living

"microscopic organisms especially, chemistry is unable "to deal, and other modes of examination are needed," the Commissioners themselves altogether omitted to have recourse to "other modes of examination," and thus, unfortunately, they were left in the dark as to some of the most important characteristics of the waters.

The Commissioners, it is quite true, make allusions to the quality of the organic matter in the waters, so far as it could be determined by chemical aid. Essential, however, as it really is to know the chemical quality of waters, it must be remembered that a concurrently conducted microscopical examination is equally essential to enable a correct judgment to be formed as to their wholesomeness and freedom from pollution.

Particulars respecting the minute vegetable organisms, fungi, and the minute living animals that are found to pervade certain waters, and whose presence, quantity, and character convey important indications of the quality, can only be ascertained by aid of the microscope: this omission of the Commissioners to subject the waters to such examination is the less excusable, because, in 1850, Arthur Hill Hassall, M.D., F.L.S., made known particulars of his microscopical examination of the organic contents of the waters then supplied to London.

In the middle of June, 1852, Dr. Lankester, F.R.S., and Professor Redfern, M.D., gave evidence before a Select Committee of the House of Commons, then sitting on the Metropolis Water Supply, on the contents of impure waters as revealed by the microscope. Owing, however, to the Committee of that day—only 22 years since—coming to a resolution not to receive the microscopical evidence prepared to be submitted to them on the character of the waters delivered to the consumers in London, through the pipes of the various companies, these revelations were not made public until towards the end of the same month, when two reports embodying the same, one by Dr. Lankester "On the Organic Contents found by the Microscope in Waters

supplied from the Thames and other sources," the other by Dr. Redfern "On the Organic and other Solid Matters found by Microscopical Examination of the Waters supplied from the Thames and other sources," were printed and extensively circulated. These examinations show that water from the Thames, at Thames Ditton, filtered and delivered into London through the pipes of the Lambeth Company, contain in half a gallon as many as 29 different species of minute living plants and animals—namely, 10 species of plants, and 19 species of animals, common enough in impure waters.

In an appendix to the Report of the Committee for Scientific Inquiries in Relation to the Cholera Epidemic of 1854 (Medical Council of General Board of Health), printed and published in 1855 by order of Parliament, will be found a minute and most instructive account of the microscopical examination of different waters (principally those used in the metropolis), by Dr. Hassall.

Again, in 1857, another report, addressed to the then President of the General Board of Health, by Dr. Hassall, contains the results of elaborate microscopical examinations of the organic contents of the metropolitan waters ever since supplied by the various companies under the provisions of the Metropolis Water Act, 1850. This report also was printed and published by order of Parliament, and shows that Thames water got at Hampton, after being filtered and conducted to the metropolis through the pipes of the companies, contains abundance of minute organisms, vegetable and animal. It then proceeds:

"It follows that the metropolis is still supplied with water con-
" taining considerable numbers of living vegetable and animal produc-
" tions, and which are not present in the purer waters, as, for example,
" that supplied by the Plumstead, Woolwich, and Charlton Company.
" Contrasting these results with those obtained by the microscopical
" examinations of the waters supplied to the metropolis in 1854, that
' is, prior to the new Act coming into operation, great improvement
" is undoubtedly manifest in the condition of the present supplies, as
" shown by the colour and taste of the waters, as well as by the
" diminished number of organic productions contained in them.

"It should be recollected, however, that the present examinations "have been made in the midst of winter, that is, at the period most "unfavourable to the development of animal and vegetable life; the "water now supplied to the metropolis is therefore in the purest state "of which, under the present arrangements, it is susceptible. It is "obviously proper that fresh examinations of the waters of the several "companies should be made in the spring, summer, and autumn in "order that their conditions at those seasons might be determined."

Notwithstanding so wise a recommendation, no such fresh microscopical examinations have been made by order of Government. Neither was this important recommendation attended to by the late Royal Commissioners; as before stated, they altogether ignored the aid of the microscope to assist them in coming to reliable conclusions upon the character and wholesomeness of the numerous and different waters that came under their notice; in consequence many of the essential conclusions in their report, founded, as they were proved to be, upon insufficient data, can only be regarded by those more fully informed as containing grave inaccuracies. To give one instance, with the results before them of a proper microscopical examination of filtered Thames water as delivered to the consumers, the Commissioners could not have ventured to put deliberately forward, paragraph 260, "That there is "no evidence to lead us to believe that the water now "supplied by the companies from the Thames basin is "not generally good and wholesome," the more especially so, when the paragraph above quoted is found to be in direct contradiction to the evidence given by Dr. Frankland, F.R.S.—paragraph 200—and to that of other earnest witnesses examined by the Commission, and is opposed to the deliberate conclusion of the late Professors Graham and Miller and of Professor Hoffman, appointed in 1851 by Government as a Commission to report on the chemical quality of the supply of water to the metropolis.

It cannot be too widely known that uncontaminated deep spring or subterranean water (so abundantly, so readily, and so cheaply obtainable from copious stores treasured up in capacious natural reservoirs

formed by minute but numerous pores that pervade the thick strata of chalk, new red-sandstone rock, upper and lower green sand, and other porous geological formations, and abundantly and continually replenished by the rains that fall upon the large area of their exposed and absorbent surfaces), is found free from all living vegetable or animal productions, and from all putrescible organic matter.

Such water has an uniform normal temperature, being at the source the average of the climate for the year, which in this country differs but little, being about 50 degrees Fah. It is at all times clear, colourless, bright, well aerated, holding in solution seven to eight cubic inches of air per gallon, and it is wholesome, pleasant, and fresh to the taste.

On the other hand, river, stream, flood and surface waters impounded in lakes or ponds, have a normal temperature near the freezing point in winter, and often as high as 70 deg. Fah. in summer.

These waters, even after careful filtration, are frequently and unavoidably delivered to consumers discoloured, and repulsive to the sight when seen in large bulk, as in a bath, although in this respect they may pass muster when seen in small quantity, as in a tumbler.

Even careful filtration through the best filters does not separate or free the waters from decaying organic matter held in solution, from urine, from minute living animal organisms that feed and grow on impure contents of waters, and which so rapidly increase and multiply therein, more especially when the water is comparatively warm, as in summer and autumn, seasons of the year when it is most abundantly drunk.

Many large provincial towns and other populous places within the last few years have happily abandoned the water of rivers for domestic use, and have since taken their supply from subterranean sources ; for example :—

The towns and parishes of Plumstead, Woolwich, Charlton, Deptford, and Greenwich, for some years past have abandoned the use of water from the river

Ravensbourne and have since taken their supply from a subterranean water obtained from the chalk strata.

The town of Hull and its suburbs have abandoned the use of water from the river Hull, and take the whole of their supply from a subterranean water obtained from the chalk.

The town of Nottingham and its suburbs have abandoned the use of water from the river Trent, and take the whole of their supply from a subterranean water obtained from the new red-sandstone.

The town of Birmingham and its suburbs have abandoned the use of water from the river Tame, and take the greater portion of their supply from a subterranean water obtained from the new red-sandstone.

The City of Canterbury and its suburbs have abandoned the use of water from the river Stour, and take the whole of their supply from a subterranean water obtained from the chalk.

Numerous other important towns derive the whole of their supply from subterranean sources; among these may be enumerated Aylesbury, Birkenhead, Brighton, Coventry, Croydon, Dover, Margate, Ramsgate, Redhill, Salisbury, Tranmere, Tring, and Wallesley.

A few large cities derive their supply from natural lakes; many from rude artificial basins or lakes, formed by placing earthen embankments or dams across suitable valleys, that serve to collect together and store the perennial stream, and the flood waters that, after great and sudden falls of rain, flow down the valleys from above. These dams form lakes which, when full, frequently cover from one to two hundred acres of land with water, shallow at the upper end of the valley, and from 80 to 100 feet deep lower down near the dam. These lakes, like rain-butts, are sometimes full to overflowing, at other times nearly empty.

The insides of the lakes are formed in a gross manner by the land in its natural state; the soil, and the grass and shrubs on its surface, being left to be covered with water when the lakes are full, and to be exposed to sun and air when they are empty.

The areas or surfaces of uplands that drain into such lakes, vary from one thousand to five or six thousand acres ; large portions of such areas are often covered with peat, the rest with heather and grass which afford cover for grouse and food for sheep. The flowing stream and the rapid flood necessarily bring with them leaves, blossoms of trees and shrubs, the droppings of birds and animals, with portions of peat and other impurities into the lakes ; in this manner the bottoms and sides get covered in many parts with organic matter that soon decays and forms offensive mud. Living organisms find a congenial habitat in the mud and water, and rapidly increase and multiply, more especially in the warmer seasons of the year.

Water so impounded frequently contains in chemical solution but few (only two or three) grains of mineral matter per gallon ; this is known as soft water. Judging, then, only from chemical analysis, this class of water, more especially when taken for examination in cold seasons of the year, might be considered to be fit for domestic use. On the other hand, these waters, more especially if taken in the warm seasons of summer and autumn, and subjected to microscopical examination, must be pronounced, owing to the quality and quantity of their organic contents, living and dead, to be, even after filtration, quite unsuited for drinking, and for domestic uses.

While river, and flood waters impounded in lakes, vary considerably in the hot and cold seasons of the year, as regards the quality and quantity of their organic contents, it is found that uncontaminated subterranean waters, at all seasons, are quite free from organic pollution. The hot and cold seasons of the year, which so much affect surface waters, have no effect upon waters buried in the deep recesses of the earth.

Having lately had occasion to submit to the eminent surgeon and microscopist, Mr. Jabez Hogg, for microscopical examination, many samples of these two classes of water—one class surface waters—obtained from

rivers and artificial lakes, mostly in use to supply some of our large cities or towns;—the other class subterranean waters—obtained from wells, some in their normal state, others contaminated with soakage from foul or sewage water, I have caused the results to be printed for ready reference and use, together with a suggestive letter from Mr. Hogg, containing much valuable information, followed by an analysis by Mr. Dugald Campbell, the eminent chemist, of two of the waters—one a surface water from the upland stream, the other a subterranean water from the new red-sandstone geological formation in Yorkshire.

S. C. H.

In Appendix to Report of the Committee for Scientific Inquiries in Relation to the Cholera Epidemic of 1854, page 217, will be found the following remarks by Dr. Hassall, F.L.S., in reference to his valuable report on the microscopical examination of different waters during the cholera epidemic of 1854 (General Board of Health) :—

"The greatest and most important contamination to which water "is prone is that by organic matter. This may exist in water in "several forms and states. It may be either dead or living, vege- "table or animal, solid or fluid, and it may be present in water in "all these different forms and states.

"Now organic matter has a chemical constitution wholly distinct "from that of water, its great distinguishing characteristic being "that it contains nitrogen, which is greater in amount in animal "than in vegetable productions. No constituents enter into the "composition of chemically pure water out of which living organic "productions can be developed, or if developed, sustained. The "presence of these affords evidences of contamination with nitro- "genous matter, and they are to be regarded as a sign of impurity. "Since the majority of organic productions are nourished by imbi- "bition, their existence in water implies the presence of organic "matter in a fluid state capable of being absorbed into their systems, "and of sustaining them. Some of the higher forms of infusoria "have, however, stomachs, and feed upon solid organic matter, either "living or dead.

"If these premises are correct, as they unquestionably are, we "repeat that the presence of organic matter in water, whether in "the fluid state or solid, and dead or living, animal or vegetable, "and especially living animalcules in water, are to be regarded as "undoubted proofs of contamination or impurity.

. . . . . .

"It is of extreme importance that correct notions should prevail "respecting the real significance of the presence of animalcules and "other minute forms of organic life in water; for much error exists "on this subject in the minds of the public, and even on the part of "some few men professing acquaintance with the laws of science.

"Many of the public believe that everything we eat and drink "teems with life, and that even our bodies abound with minute living "parasitical productions. This is a vulgar error, and the notion is as "disgusting as it is erroneous."

REPORT

ON

THE MICROSCOPICAL CHARACTERS

OF CERTAIN

SPECIMENS OF WATER

SUBMITTED TO

JABEZ HOGG,

Surgeon to the Royal Westminster Ophthalmic Hospital; President of the Medical Microscopical Society; Fellow of the Royal Microscopical Society, &c.; author of a work "On the Microscope," "On the Ophthalmoscope," "Parasitic Diseases of the Skin," &c.

On the 19th of June I received from Mr. Frederick Fowler, of Sheffield, eight Winchester quart bottles of water, labelled and sealed, four of which were taken two days before from a reservoir of the Sheffield Water Works Company, "The Godfrey Dam"—temperature when collected 56 degrees Fah.—and four from the Selby Water Works, normal temperature 50 degrees Fah.

Sheffield W. W. Source—Stream and flood water from upland of millstone grit geological formation, having surface, partly covered with heather, moss, and peat; partly covered with grass, impounded in a rudely constructed artificial lake, formed by placing an embankment of earth across a valley, one of the tributaries of the river Don, situated about six miles west of the town. The lake is deep at one end shallow at the other, with sides and bottom more or less covered with mud and *debris* washed down by floods; sometimes full to overflowing; sometimes empty.

On pouring out the water taken from the Godfrey Dam into a quart measure of white glass it had a yellowish brown hue, and on standing half an hour a considerable deposit was thrown down.

On collecting this sediment, and placing it under the microscope, it was seen to consist of masses of organic matter, living animals, &c.

The living organisms were well known infusorial animalcules, entomostraca (water-fleas, some visible to the naked eye), daphnia pulex, paramœcium, rotifers, and cercomonas; anguillula fluviatilis (a species of eel-like worm, found mostly in rain water), amœbæ, actinophrys sol (sun-animalcule), and larval forms of smaller

animals, together with spores (protococcus pluvialis), portions of confervæ, desmids, and numerous fragments of decaying vegetable matters, such as are usually found in river and pond waters.

The sediment was again examined on several occasions after standing exposed to sunlight, and lightly covered, when the same forms of animals and vegetables were recognised. Some of them were more numerous than before, and a careful drawing was made of them by an artist accustomed to draw from the microscope.

The presence of these forms of animal and vegetable life, especially in such large quantities, indicate a water exposed to contaminating influences, such as surface water obtained from a lake with a muddy bottom, and holding in solution decomposing organic matters highly injurious to health.

During warm weather and an increased temperature, both animal and vegetable organisms always rapidly multiply in such waters, and as a considerable quantity of organic matter is held in solution, no filtration will render them wholesome, or convert them into good potable waters. The ova of minute animal and vegetable life invariably find their way through the best filtering beds. The paramœcium animalcules are well known to be the cause of serious forms of illness, summer diarrhœa, &c.; even animals suffer from drinking water in which these animalcules abound; and some larval forms living in water have to pass through the stomach of animals before they are known to affect human beings. The anguillula fluviatilis, for instance, which infests the intestinal canal of fishes, is believed to originate the dreaded trichina disease. The microscope has more recently detected the presence of infusorial animalcules (bacteria) in the blood of some hospital patients after operation, and of those who die from what is termed *blood-poisoning*. Minute vegetable fungoid bodies attack fish and often kill them; and cows and sheep, as well as fish, have been known to be poisoned by drinking water from a stream contaminated with putrescible vegetable matter, the

refuse of a starch manufactory on its bank, and which no filtration would remove or separate.

Samples of water, labelled "Selby Water," were examined in the same way. On pouring out the water into a white glass measure, it was clear and bright, and on standing deposited scarcely any sediment. Specimens of the collected deposit, examined under the microscope, were quite free from all forms of animal life, and only a very few fragments of vegetable and mineral matters were found.

Selby W. W. Source—Well 11 feet deep, with small bore taken to the depth of 325 feet below the bottom through a bed of clay 81 feet thick into the new red-sandstone geological formation.

On the 15th of June Mr. Dugald Campbell, of Quality-court, Chancery-lane, placed in my hands four other samples of water taken on the 9th.

No. 1. From the stream at the site of the proposed reservoir at Langsett (near the head of the river Don, Yorkshire), for the supply of Wakefield.

Stream water from upland of millstone grit, at the head of river Porter or Little Don, having surface partly covered with heather and peat; partly covered with grass; situated three miles south-west of Penistone.

On decanting this, and collecting the sediment for examination under the microscope, I found it presenting all the appearances described in my examination of specimens taken from the Godfrey Dam Reservoir. It was brownish in colour, and abounded in animal and vegetable organisms, chiefly paramœcium, trichoda, rotifers, cercomonas, protococcus pluvialis, confervæ, and numerous fragments of decaying mosses, and of vegetable matter. This also indicated a water exposed to contaminating influences, containing putrescent animal and vegetable matters, a good deal of which is held in solution, to the injury of the health of those who use it for drinking and dietetical purposes.

No. 2. From a well at West Cowick Brewery, near Snaith, Yorkshire.

Well sunk in red-sandstone, contaminated by soakage from foul water.

On decanting, only a very small quantity of sediment was thrown down, and this was found to be composed of the remains of mineral, animal, and vegetable matters, with a few living vegetable spores, but no animal organisms. This water, although free from living animal organisms, gave strong indications of nitrogenous contamination. The permanganate of potash

quickly became oxidised, and the characteristic absorption bands rapidly disappeared from the spectrum when under examination by the micro-spectroscope.

Well sunk about 70 years since in red-sandstone, having water contaminated by soakage from adjoining grave-yard and drains; situated at a low level in the town.

No. 3. From a well at Snaith Saw Mills.

On decanting, this is seen to have a strong brownish tint, and a considerable deposit falls to the bottom of the glass vessel. A small quantity placed under the microscope is seen to contain numerous animal and vegetable organisms, as paramœcium, rotifers, actinophrys sol, cercomonas, confervæ, desmids, and decaying vegetable matter, probably derived from sewage contamination, and likely to prove a source of disease.

Well sunk in red sandstone, having water fouled by soakage from an adjoining drain and overflow from a cesspool.

No. 4. From a shallow well at or near a farm-house.

On decanting, only a small quantity of sediment falls down; this is composed of the remains of animal and vegetable life, hairs of plants, and the outer cases of acari. Organic matter is held in solution, and the water is probably contaminated by sewage, as it decomposes the permanganate of potash, and in a short time removes the absorption bands from the spectrum.

On the 19th of June Mr. Fowler forwarded to me by railway four other samples of water taken on the 17th and 18th, by his assistant, Mr. Robertson.

Sheffield W.W. Source—Soft surface water, impounded in open lakes as before described.

No. 5. Taken from a tap supplied direct from the mains of the water company at the Sheffield and Rotherham Bank, Sheffield. Temperature when drawn 55¼ deg. Fah.

On decanting, and allowing it to stand for half an hour, a considerable quantity of sediment was thrown down; nevertheless it remained slightly turbid, and of a brownish tint. Small quantities of the sediment examined under the microscope were seen to contain numerous animal and vegetable organisms. After a few hours' exposure to warmth and light, the smaller animals increased and moved about more briskly. As in the first specimen examined, I found entomostraca (water-fleas), paramœcium, amœbæ, cercomonas, protococcus pluvialis, confervæ, desmids, the debris of mosses and

decaying vegetable matters, all indicative of a surface water of a very inferior quality.

No. 6. Taken from a tap supplied direct from the water mains of the water works to the Globe beerhouse, Wakefield-road, Dewsbury. Temperature when drawn 56½ deg. Fah.

Dewsbury W. W. Source—Stream and spring water mixed, derived from upland of millstone grit; situated six miles east of Penistone.

On standing, a small deposit is thrown down, and this under the microscope is seen to be fragments of organic and mineral matters. On exposure for 24 hours very few living animals were developed.

No. 7. Taken from a tap supplied direct from the mains of the water works to the first-class refreshment rooms of the Manchester, Sheffield, and Lincolnshire Railway Company, London-road Station, Manchester. Temperature when drawn 57 deg. Fah.

Manchester W. W. Source—Mixed stream, spring, and flood water impounded in artificial lakes, derived from upland of millstone grit, having surface partly covered with moss, peat, and heather; partly covered with grass, and partly bare; stored for distribution in open reservoirs; the water derived from higher portion of hills situated 12 to 20 miles east of the city.

On decanting and standing by, only a small amount of sediment was thrown down; specimens of this were found to consist of organic matters, animal and vegetable, chiefly larval, as cercomonas, amœbæ, vorticellæ (bell-animalcules), confervæ, and minute vegetable bodies, which, on exposure to sunlight, were found to increase in numbers.

No. 8. Taken from a tap supplied direct from the mains of the water works to the lavatory of the King's Head Hotel, Barnsley. Temperature when drawn 56 deg. Fah.

Barnsley W. W. Source—Stream and flood water from upland of millstone grit, impounded in artificial lake; situated about eight miles west of the town.

On standing, this deposits only a small quantity of sediment, which is seen to be chiefly vegetable organic matter, hairs of plants, spores, and scales of insects, bodies usually discovered floating about in the air of most towns and country places. This water remains clear and limpid after standing in an exposed situation.

No. 9. A specimen placed in my hands June 29th, by Mr. Campbell, from New Well in red sandstone, at proposed pumping station Little Heck, taken on the 27th ult. Normal temperature 48¾ deg. Fah.

Well recently sunk in the new red-sandstone geological formation situated near to the York Selby, and Doncaster Railway, five and a half miles south of Selby.

This water, on standing, remains clear and bright. It is perfectly free from organic matter of every kind.

The microscope discovered only some minute mineral matters. It is fresh and agreeable to the taste, colourless to the eye, and pleasant to the touch; a moderately soft washing water. By far the best specimen of water examined, and a very suitable one for dietetic and household purposes.

Wakefield W. W. Source—River Calder, two miles below the town; passed through filters containing magnetic oxide of iron, and then pumped through pipes direct to the houses of the consumers, or into an uncovered service reservoir.

No. 10. Drawn from a tap (supplied by Water Company) of Mr. George Marriott, Wakefield, July 4th, 1874, in the presence of Mr. Fred. C. Jennings, surgeon, and forwarded by rail to me same day. The latter gentleman appends a note to the effect "that the source whence the company take their supply is unprecedentedly low, and that large animalcules are now plainly visible to the naked eye." Temperature when drawn 62½ deg. Fah.

The colour of the water was of a brownish tinge, and on shaking the nose detected a faintish sewage odour. After standing, the amount of sediment was not large, but this, on examination, proved to be organic matter. It consisted of the outer cases of entomostraca (water fleas) of a considerable size, infusorial animals, wheel animalcules, stentors, paramœcium, cercomonas, &c., vegetable matter, confervæ, diatoms, and decaying fragments of peat and moss. On testing a portion with the permanganate of potash it became in a short time of a brickdust red colour, and the absorption bands were in six hours removed from the spectrum.

With regard to the specimens of Sheffield Water Works water, I would remark that they contain very many of the same forms of organic germs generally found in Thames water before filtration, and in point of putrescent matters they are little better than Thames water of some twenty years ago, and only slightly differ from the water of St. Mary's Loch, which was rejected by the House of Lords some three years ago, when proposed for the supply of Edinburgh.

There are one or two points that deserve particular attention. First, as to the tenacity of life of the lower forms of animals. Very many animalcules' eggs are

but little affected by temperature; the ordinary heat employed in culinary operations does not always kill them nor a long drought or intense frost destroy their vitality. Secondly, as to the relative hardness or softness of potable waters, these are terms which convey very little information as to their salubrity, for while no one has asserted that a moderate quantity of mineral matter, carbonate of lime, in water is prejudicial to health, every medical man of experience will agree with me that living organisms and even small quantities of putrescent organic matters are extremely dangerous. There can scarcely be a second opinion that water so contaminated is insalubrious and unfit for drinking and culinary purposes, and since this is unavoidably the condition of surface waters, "we must all hope to see the time when our towns, ceasing to be supplied with the waters of rivers or lakes, will derive their drinking water wholly from deep springs."

(Signed) JABEZ HOGG.

1, *Bedford-square,*
July 7th, 1874.

1, Bedford-square,
London, July 8th, 1874.

DEAR SIR,

After having read over the printed minutes of the evidence to which you drew my attention, it has occurred to me that the following observations may tend to make more clear the value and the bearing of the results of the microscopical examinations of the water I lately sent you.

The impounding and storage of stream or flood water, mixed as such water more or less must be, with leaves, droppings of animals, and other organic impurities, in large, open, rudely-constructed reservoirs or lakes, freely exposed to both sun-light and air, necessarily causes grave contaminations, especially in warm summer

weather, as it is during this period of the year that the generation and rapid growth of organisms, vegetable and animal, takes place from spores conveyed into the water by rain and air, to live, propagate, and die, and become putrescent.

These conditions are for ever recurring, and thus when water remains at rest, or moves but slowly, as in lakes, canals, and open reservoirs, living organisms and putrescible matters accumulate, get diffused, or sink, and render the water unsuited for human consumption.

In my experience it is quite at variance with the fact to say that, because certain aquatic weeds grow in a stream, their presence necessarily proves the water to be wholesome; certain species of unicellular algæ will grow abundantly anywhere; and the Thames at Richmond, and during its worst periods, abounded in such weeds as the anacharis alsinastrum (water thyme), ranunculus aquatilis (water crowfoot), &c.

It is utterly wrong to suppose that a dilution of twenty times with purer water renders a contaminated water (that is water contaminated with one-twentieth of sewage), even after running together for some distance in a stream, fit for dietetic uses; a much larger dilution than this has been known to produce cholera and typhoid fever. Indeed, the fallacy of such an assertion becomes apparent when it is remembered that the one-hundredth thousandth part of yeast (*Mycoderma cerevisiæ*) a minute fungus, which the microscope shows to consist of myriads of living cells, or vesicles; when added to a vat of sweetwort, with a marvellous rapidity of growth, converts it into an intoxicating drink; and if the growth of the fungus is not stopped at the right moment, putrefaction sets in, followed by animal organisms that change it into vinegar.

It would be a grave error to imagine that because filtration removes the larger and full grown entomotraca (water fleas, &c.), it will also separate and remove their eggs and the smaller animalcules, some of which are not more than the one 20 or 30 thousandth part of an inch in size. These find their way through the

most perfectly constructed filter beds. Even filtering through carbon, or magnetic oxide or carbide of iron, in no way affects or kills these living eggs and organisms, or deprives the water of them, although it may make the water clearer and brighter, and may "force the sulphureted and phosphureted hydrogen, sometimes found in foul water, into combination with oxygen."

The microscope readily detects the minuter forms of organic life in water so filtered; in skilled hands it also enables the medical man to distinguish from each other healthy and diseased cells, the bacteria and microzymes of septic poison, the specific poison cells of ophthalmia, of small-pox, of sheep-pox, of vaccine, and such like minutely organised granular bodies, varying in diameter or size, from the one five thousandth to the one fifty thousandth of an inch.

One of the latest contributions of the microscope to medicine and to our knowledge of entozoa (parasitic internal worms) is, that a nematoid worm will find its way into the blood of a man and multiply there in thousands. These thousands of living, active, propagating worms are, it is believed, conveyed into the blood-vessels in the fluids taken, doubtless, by the water drunk.

The Delhi or Damascus sore, a disease that has spread all over the East, has by the microscope been discovered to be produced by a minute vegetable cell, very like the yeast plant, that grows marvellously fast, and very soon destroys large portions of the skin, and ultimately kills the patient.

The fungus foot disease of India is also due to an algæ or fungus; and this produces a great amount of disease among the native population, frequently the loss of a foot or a hand of those afflicted. The fungus alluded to is supposed to be conveyed into the circulation by drinking contaminated water. A fresh water unicellular algæ (*sarcina ventriculi*) is often found in the human stomach, and is productive of a distressing form of disease. This has also been traced to drinking impure water.

In short, it has been satisfactorily proved, "That no vehicle of disease is so fatal as drinking-water. If water were always pure, cholera would be almost banished, and the risk of typhoid fever reduced by more than one-half. And though it is known what harm bad water can do in cases of infectious disease, no one can accurately estimate the extent to which other complaints come from the same cause, or how far its effects may be traced in a condition of general ill-health almost as mischievous, in the long run, as acute disease."

I remain, yours faithfully,

JABEZ HOGG.

S. C. Homersham, Esq., C.E.,
19, Buckingham-street, Adelphi, London.

NOTE.—The drawings at the end show, as seen through a microscope, some species of the animals and plants referred to in the foregoing pages; the larger creatures are magnified 30 diameters, while the smaller are magnified 350 diameters and upwards.

CHEMICAL REPORT

BY

DUGALD CAMPBELL, F.C.S.,

Analytical Chemist to the Brompton Hospital.

7, Quality-court, Chancery-lane,
London, July 6th, 1874.

SIR,

I beg leave to report to you the results of my examination of two samples of water, one received on the 24th of April last, marked "Sample No. 1, F. F.," and the other received on the 29th of June instant, marked "No. 2, Water from New Well sunk in red-sandstone at proposed pumping station, Little Heck, Yorkshire; normal temperature, 48¾ deg. F., June 27th, 1874, 4 p.m.; sent by Mr. T. Raper, Snaith."

"Sample No. 1, F. F.," is the water taken from the stream at site of the proposed reservoir at Langsett, for the supply of Wakefield; on examination it was found to be as follows:—Of a yellow tinge of colour, and on standing it gave a light brown deposit, which was separated and examined under the microscope, but not minutely, was found to consist of oxide of iron, animalcules, and vegetable matter alive and dead.

The total Solid Matters in a gallon were ...	4·40	grains.
consisting of		
Mineral Matter	3·20	,,
Volatilised Matters which blackened when heated	1·20	,,
Degrees of Hardness...	1·20	,,
Ammonia in solution in the water	·006	,,
Ammonia combined in the volatilised matter	0·020	,,

This latter substance, sometimes called albuminoid ammonia, when in any notable quantity is considered a dangerous element in water for drinking purposes, and it is here in much larger quantity than it is usually met with in potable waters.

"No. 2, Water from New Well, sunk in red-sandstone, at proposed pumping station, Little Heck, Yorkshire; normal temperature, 48¾ deg. F., June 27th, 1874, 4 p.m.; sent by Mr. T. Raper, Snaith," when viewed in bulk was colourless, but gave a very slight deposit, which when separated and examined under the microscope was found to be nothing but sand.

The total Solid Matters in a gallon were ...	11·84	grains.
consisting of		
Mineral Matter	10·40	„
Volatilised Matter which does not blacken ...	1·44	„
Degrees of Hardness	6.5	„

The mineral matter was of the following composition:—

Silica	0·40	„
Oxide of Iron	a trace.	
Carbonate of Lime	none.	
Sulphate of Lime	1·40	„
Nitrate of Lime	3·22	„
Sulphate of Magnesia	2·83	„
Carbonate of Magnesia	0·60	„
Chloride of Potassium	0·50	„
Chloride of Sodium	1·38	„
Loss in Analysis	0·07	„
Ammonia in solution in the water	0·002	„
Ammonia combined in the volatilised matter	0·001	„

It will be observed that the ammonia in solution in this water is much less than the ammonia in the proposed Wakefield water, and that the combined

lbuminoid ammonia is a mere fraction of what is con-
nined in it, being only the one-thousandth part of a
rain in a gallon, and this may have been caused by the
nen so recently working in the well.

In conclusion, I may observe that this water is very
imilar in its chemical composition to the water of a
vell belonging to the London and North Western Rail-
vay Company, at Warrington Junction, Lancashire,
unk in the red-sandstone, and which I have twice
examined, once in March, and again in April, 1865, and
which I then reported was in every way a good water
for domestic and culinary purposes.

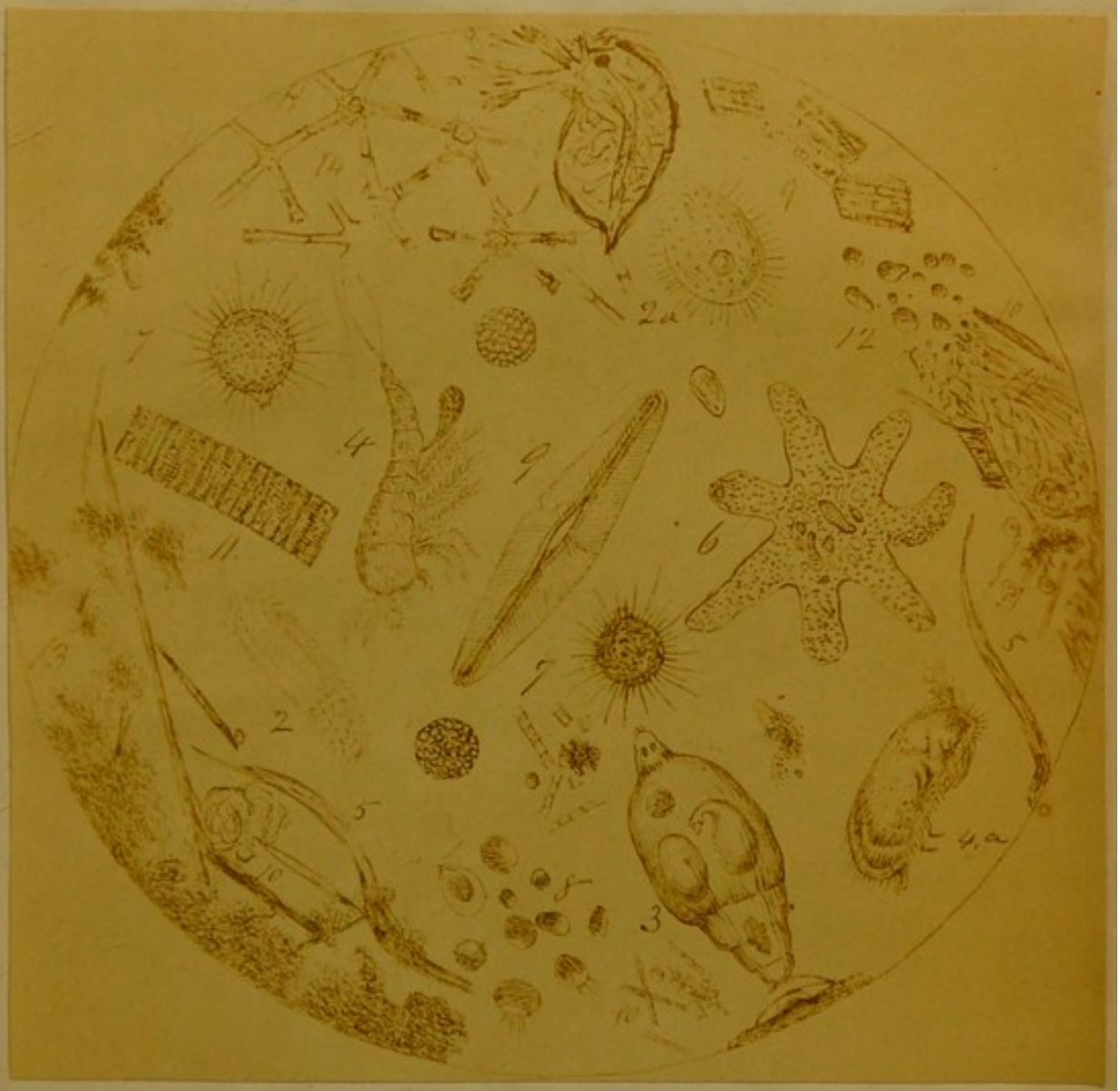
I am, Sir,

Your obedient Servant,

DUGALD CAMPBELL.

S. C. Homersham, Esq., C.E.,
19, Buckingham-street, Adelphi, W.C.

Photo-Microscopical Drawing of the Sediment of Water taken from the Sheffield Water Works Reservoir, "Godfrey Dam."



INFUSORIAL ANIMALCULES, ENTOMOSTRACA, &c.

1. Daphnia pulex. 2. Paramœcium. 2*a*. Glaucoma scintilans. 3. Rotifer, with its rotary discs closed up 4. Cyclops quadricornis. 4*a*. Cypris. 5. Anguillula fluviatilis. 6. Amœba diffluens. 7. Actinophrys sol (sun animalcule). 8. Cercomonas. 9. Diatoms. 10. Desmids. 11. Confervæ. 12. Spores of fungi. 13. Masses of decaying vegetable matters. 14. Stellate tissue of a rush.


ROYAL COLLEGE OF SURGEONS OF ENGLAND
12 JUL 12