Dr. Thresh had several oysters dredged up from the bed, and has made a bacteriological examination of the mud on the shells, the liquid in the pallial cavity, and in the substance of the oyster. By cultivating in phenolated broth, and by growth on gelatine plates, he isolated organisms which resemble in many respects the bacillus coli and the bacillus typhosus, but which could not be absolutely identified with either. The organisms referred to grow in phenolated broth, curdle milk, produce air bubbles in gelatine, but do not give a distinct indol reaction. The pollution of the foreshore at Brightlingsea has been referred to several times by Dr. Cook, the Medical Officer of Health to the district, and it is hoped that this outbreak will cause the sanitary authority to take immediate steps to remedy a condition of things which is not only a danger to the inhabitants, but also to the visitors and others who consume the oysters fattened under such objectionable conditions.

CRENOTHRIX POLYSPORA (VAR.) CHELTONENSIS.

A HISTORY OF THE REDDENING AND CONTAMINATION OF A WATER SUPPLY, AND OF THE ORGANISM WHICH CAUSED IT; WITH GENERAL REMARKS UPON THE COLOURATION AND POLLUTION OF WATER BY OTHER ALGÆ.

BY

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THE water supply in question constitutes at the present time the chief supply to Cheltenham. It comes from the Dowdeswell Reservoir which is filled from the head waters of the little river Chelt, and which holds when full 100,000,000 gallons. The two chief streams unite before entering a settling pool placed at the head of the main reservoir, and separated from it by a dam of masonry, whilst some minor streams which rise in springs not very far away run straight into the main reservoir. The steep slope on one side of it is covered with a thick wood, and several small springs rising in boggy ground in this wood send down their water to join the main supply. In some places on the wood side of the reservoir, and in the banks of the upper pool, there are small springs of water surcharged with ferrous carbonate, the presence of which is made evident by the ochreous deposit in the course of the streamlet. A trace of iron may always be found in the water as delivered to the town, the quantity being however, too little to make it worthy of special note from an analytical, or sanitary point of view. The water of the chief springs forming the fountain heads of the Chelt is thrown out from the oolitic limestone, the escarpment of which rises some hundreds of feet above the lias clay, and partly

surrounds the reservoir. A considerable portion of the water collected, however, is from the surrounding upland surfaces of cultivated ground, and the whole of the water consequently requires to be submitted to filtration before being supplied to the town. The water is alkaline to an equivalent of some 15 parts of calcium carbonate in 100,000, and normally contains about 2 parts of chlorine and .5 of nitric acid per 100,000. The supply of water during the winter months is usually more than sufficient to fill the reservoir, so that by the early spring of each year there is an overflow, and for some weeks at least a considerable stream passes through the reservoir over and above that which is utilised to supply the town. An exception to this rule occurred last winter, when, owing to the diminished rainfall, there was not sufficient water to fill the reservoir, and there was consequently no overflow in the spring of this year, as there had been in every previous year since the reservoir was made ten years ago. This fact affected the quality of the water to some extent, and may have been the cause of the phenomenon, which was never before observed.

Complaints arose, in the spring of this year, of an odour and turbidity in the water supplied to the town; the odour was observed particularly by those who used hot water for baths. On March 1st a swimming bath belonging to a large boys' school was filled for the first time this year, when it was noticed to be rather red and turbid. It happens that the three or four other swimming baths in the town are filled with water derived from other sources, and in these the water was of normal appearance. The possibility of an accumulation of iron rust having occurred in the boiler and pipes connected with the bath since last it was used was a suggested cause. Complaint was not made in regard to it until some weeks later, when, upon refilling the bath after a holiday interval, the water was found to be much worse in appearance, and so turbid that the bottom of the bath could only just be seen at a depth of $3\frac{1}{2}$ feet. A little later it was discovered that the whole bulk of the water contained in the reservoir had assumed a red colour. At a visit on April 20th, the water in the reservoir was of a brown-red colour, and turbid. At this time the gauge marked a depth of 28 feet 11 inches of water, which is equivalent to over 84,000,000 gallons. The water in the upper settling-pool, into which the Chelt first flows, had the normal green colour which usually characterises it, and offered a striking contrast to that contained in the main reservoir, from which it was simply divided by the dam. The reason of the upper pool not being affected in the same way as the reservoir evidently lay in the fact of the constant flow through it of a large quantity of fresh water, whilst the lower pool, being of infinitely greater size, was in a condition of comparative stagnation. It was at once divined that

the colour was due to the growth of an organism. The water from the reservoir, examined in a long glass beaker, was seen to be decidedly turbid, and to have a distinct red tinge. The filtered water, taken from the tank which received the water from the filters, presented the same appearance in a lesser degree; and it thus appeared that the sand filters were incapable of removing the whole of the fine suspended matter which was giving colour and turbidity to the water. The necessity of frequently scraping the filters at that time was conducive to this result. The surface of the filters was reddened, and from a heap of dirty sand scraped from the filters' surface a red fluid was draining.

At what exact date the development commenced is uncertain, but it must have been in the cold months. The complaints arose chiefly in April and May. From April onward the redness and turbidity in the water came to a climax; then, after passing through some alterations in shade of colour, it somewhat suddenly recovered its normal appearance. The following chronological notes will give some further indication of the changes which occurred:—

March 1st.—The school swimming-bath first filled, and water noticed to have a red colour.

April.—Complaints made as to odour, turbidity, and deposit in the water.

April 20th.—Visited reservoir, and found the water brown-red.

April 28th.—The colour of the water in the reservoir was brown-red, with a tinge of olive. The filters become clogged within a fortnight of scraping. The greatest difficulty in this respect was said to have occurred five weeks ago. From the heap of dirty sand was draining a thick, dark-red, semi-fluid juice. Where the sun had dried it, it was almost black, and cracked and curled, having the appearance of dried blood. A gully placed near by to carry away drainage from the dirty sand, etc., had its trap filled with fluid that had the exact appearance of the washings of a slaughter-house. The contents of the gully and the thicker juice running out of the sand had a strong and very offensive odour, like that in a farmyard when the manure of a year is being removed, or of a foul privy. The water used for washing the dirty sand in the sand-washers had a strong red colour as it flowed away, and coloured red the brook into which it discharged.

May 2nd.—The reservoir to-day, being calm, looked like a great brown horse-pond. The surfaces of the filters were very red.

May 11th.—The water in the reservoir had now olive and purplish tints.

May 21st.—The water in reservoir looked decidedly less red, and more green. The surfaces of the filters were less red.

June 1st.—The water was now a dark olive-

green in colour. The turbidity was such that the bottom could be dimly distinguished at the edge at a depth of three feet.

June 3rd.—The school swimming-bath was refilled to-day, and the water was of an olive-green colour.

June 5th.—The water in the reservoir was now much more green than red.

June 10th.—The water in the reservoir had entirely recovered its normal appearance, having now its natural tint of yellowish-green; it is also much clearer. Present contents of reservoir, 69,000,000 gallons; on April 20th it was 84,000,000 gallons.

June 11th.—Heard that the water in the school swimming-bath had very much improved.

From this date onwards there was nothing further of an abnormal character to observe in the appearance of the water. There was no further reddening of the filters' surface, and no more red fluid run out of the sand removed from the filters. The quality of the water supplied to the town was also now greatly improved, being clearer and more pleasant to the palate. During the whole time that the reservoir was affected, the water in the upper pond, and that in a pond at Dowdeswell Court, half a mile distant, remained perfectly normal.

Microscopic examination of the water of the reservoir discovered the existence of a small micrococcus; and a little of the reddened sand from a filter's surface being taken and stirred with water, the washings were coloured red, and found to be crowded with the same micrococcus, whilst the thick dark red fluid which drained out of the sand heap practically consisted of nothing else but this same organism in vast numbers. The cocci existed in singles, doubles, and short chains of three or more cells, and there were also present some very small masses or zoogloæ. The cocci exhibited a very lively movement; but whether this was a vital movement, or merely the molecular or "brownian" movement, was difficult to decide. The double cells and chains could be seen to turn over and over, so that sometimes only the end cell could be seen, and sometimes the broadside. The movement of the individual cells on the microscope field was, however, chiefly of an oscillatory kind. As fixed and stained, they are represented in the photograph, Fig. 1. With ordinary preparations of aniline colours, these cocci do not stain densely. They have hardly any affinity for methylene blue. There is a clear space, or transparent envelope, surrounding the cell or the chain, which is not so apparent but that it might be overlooked. It does not stain, but appears merely as a halo of light. It is accurately shown in the photograph from which Fig. 1 is taken, but is hardly shown in the print. The colour in the water was undoubtedly due to these

cocci. The colour of the individual cocci, or of all that were in the field of a one-sixth or one-twelfth inch objective lens, being, however, too slight to be recognised.

Besides the very small zooglœæ found in connection with the cocci as collected from the sand, larger zooglœæ were found in the water from the reservoir. These occurred especially towards the end of the time when the water began to change its colour; they were also found in the filtered water as drawn from the pipes, a number of them settling down together to form a flocculent deposit when the water was allowed to stand for some hours. These zooglœæ are individually of microscopic size, and quite irregular in form. When occurring as a deposit in the water, they are generally coloured, the tint varying from a pale buff to a rich dark brown. The latter appear of a fine golden-brown colour under the microscope. This colour appears to be connected with iron

Fig. 1. $\times 1000$. Spores of *Crenothrix* as contained in the water of the reservoir and in the sand scraped from the filters.

in the water. Zooglœæ of similar colour and appearance can be formed by adding to water containing some of the cocci derived from the dirty sand a trace of ferrous sulphate. Golden-brown floccula occur which, within a few hours, are found to be full of cells. The cocci in the zooglœæ are larger in size than those that are free and mobile, and in some the cells are distinctly oval, rather than round in shape. The free cocci themselves vary considerably in size, some of them being exceedingly minute, not more than $3\ \mu$, but many of them are about $1\ \mu$. The cells of the zooglœæ may be twice this size, and larger.

Examination of the flocculent deposits contained in samples of water, derived from various house taps and house filters, revealed the occasional presence of filaments, which were originating in

the cell masses and taking the place of the cells, and ultimately from such filaments was seen the production of spore cells which varied much in

Fig. 2. $\times 500$. Filaments and Zooglœar Cells (the latter not in focus) as deposited in water drawn from house tap.

kind and size, but which had the general characteristics of the original cocci, and were produced in prolific numbers.

A further careful examination of the water in the reservoir discovered no gelatinous or considerable growth of any sort in the water at any point. Some

Fig. 3. $\times 125$. Filaments and Zooglœar Cells as developed upon one of the stones lining the sloping sides of the reservoir; all the dark parts are finely cellular.

froth, which had been blown from the surface of the water on to land and got dry, was collected and examined on July 5th, and found to consist

almost entirely of the cells in the zoogloear condition. This froth had a pale buff colour, and formed when dry a light powder. Wet froth collected at a later date from the surface of the water consisted of the same zoogloear with some extraneous debris. There was no unusual amount of frothing of the water however. The cellular structure of the froth could not be seen until it was stained, and the staining was best accomplished with fuchsin. Parts of the sloping sides of Dowdeswell Reservoir are loosely paved with stones of various sizes of oolitic origin. At the time the water was of a red colour some stones were fished up from three or four feet below the surface, and were found to have their upper surfaces coloured a little red as if by deposit of the red material in the water upon them, but there was no other growth upon them. On July 3rd, however, it was noticed that the stones left bare by the gradual sinking of the water had a growth upon them. This growth increased during July and August, reaching its maximum at about the end of the latter month. The reservoir being called upon for a large supply of water at this time, the level of the water sank constantly, and by the end of the third week in September the quantity contained in the reservoir was reduced to 25,000,000 gallons, or considerably less than one third of what it measured six months previously, and the loss in depth during the same time was fourteen feet. The stones at first left bare by the sinking of the water were mottled with the growth, and by the end of August it completely covered their exposed surfaces. This growth is very short, merely a kind of "weathering," of a pale buff or drab colour with a little green in it. It is velvety to the touch when the stone is wet. It can be easily brushed off the wet stone or even rubbed off with the finger. A portion of the most robust part of the growth, such as occurs in the little pits in the surface of the friable oolitic stone, when removed and rolled between the finger and thumb, or pressed with a needle upon a glass slide, has a doughy consistency, and may be a little gritty owing to the presence of diatoms. The microscope proves this growth to be the natural vegetative development of the organism, showing it to consist of massed zoogloear and filaments. These filaments are generally larger than those grown artificially, or found in the deposit from the water, and many of them can be seen to be divided into a distinct solid central axis and a filament wall. When the dry stone was placed under a one-inch objective lens, the appearance of the growth, before it had been teased out and stained, was like glistening heaps of gum or burst starch granules, and by the same power of the microscope a filamentous growth was seen to stretch across the pits or little chasms in the stone resembling minute broken cobwebs. When exposed to the air, the effect of wind and rain tends to clear the stone of this growth. That which remained upon a stone that

had been exposed to the air for a long time consisted merely of debris, resulting from the disintegration of cells and filaments.

An examination of some old iron water pipes that had to be supplanted by others of larger calibre showed a buff-coloured deposit. A portion of this being treated with hydrochloric acid effervesced, and was partly dissolved; a residue of flocculent matter remained, however, which, when examined by the microscope, proved to be the same organism in the zoogloear condition.

Attempts to cultivate the cocci upon artificial media were successful. On a gelatine plate they give colonies whose extension in the nutrient medium is very limited. These colonies, examined by a low power of the microscope, are seen to be round or oval, with a smooth edge, and containing more or less golden brown pigment. On agar-agar jelly at 37°C., a pale buff-coloured somewhat crumpled expansion covers the surface in twenty-four hours. On coagulated cleared serum at 37°C., in from one to two days, an almost colourless tough expansion is developed, which may easily be removed from the surface of the liquefied serum. A pale buff crumpled growth may also be obtained upon potato. These cultures were obtained from the cocci of the red fluid drained out of the sand, and precisely similar cultures were obtained from the dry froth. A small portion of the red fluid drained from the sand being placed in a beaker containing water derived from Dowdeswell Reservoir, the water was coloured red. On placing the beaker in the incubator at 37°, the red colour of the water changed to green within a few hours, and a flocculent yellow-green deposit subsided to the bottom of the beaker. This deposit consisted of cells in zoogloear, and in zoogloear thus derived from the original cocci filaments were afterwards produced. Filaments were also obtained by removing the growth obtained by planting the dry froth upon coagulated serum, and placing it in filtered Dowdeswell water. The normal summer temperature seems most favourable to the production of filaments; their formation appears to be hindered by a daily agitation, and encouraged by stagnation. When the beaker containing the zoogloear and water was set aside for three weeks, filaments were usually found to have developed by the end of that time. The young filaments are originally produced, not by the sprouting or division of each individual cell of the zoogloear, but rather by rows of these cells arranging themselves into lines, what was formerly a mass of cells becoming a network of filaments. Whilst the younger filaments freely anastomose, the older ones exhibit few branches; an occasional forking is, however, met with, but the greater part of the apparent branching is due to the overlying of one filament by another. The young filaments, carefully examined by a high power after staining with fuchsin, are invariably seen to consist of rows

of cells, and even when the filaments are quite adult, the cellular structure is still apparent in the walls. This cellulation of the organism in all its phases is striking and characteristic. To see the divisions between the cells, the preparation requires to be well stained, and a good light is necessary with the use of a diaphragm to cut off extraneous rays. The filaments obtained from the stones lining the reservoir were of a robust and adult type, and it was chiefly in these that the several ways of spore production were studied. These filaments were found susceptible to a simple double staining; being first strongly stained by fuchsin, a portion of the red colour is removed with acid alcohol, and whilst still wet with the acid, Loeffler's methylene blue solution is poured on, and the preparation warmed for a minute or two, and lightly washed with water. The central portion of the filament is stained strongly blue, the filament walls and the zooglœa present are stained maroon red. The central axis portion of the filaments divides into pieces of various sizes and shapes, most often into round cocci, which are discharged at the broken end of the filament. It is only whilst these spores are contained within the filament wall, and immediately after their discharge, that they will take the blue stain. It is probable that the larger cocci, or elongated pieces of the axis cylinder, break up after their discharge into smaller cocci (see plate at o). Another and prolific mode of spore formation is seen in certain filaments which have grown to a larger size, and which break down at their ends and sides, setting free a swarm of spores (see plate p and q). The large number of spores often seen around the zooglœa cell masses is suggestive that they may be formed directly by these without the intervention of filaments. The great number and diversity of spores formed by this organism is appropriately signified by the specific name *polyspora*, which deserves to be retained.

This organism agrees in its main characteristics with that described in Germany by Professor Zopf and others, under the name of *Crenothrix polyspora* or *C. Kuhniana*. Very little notice has hitherto been taken of it in this country; in fact, I have been unable to find any reference to it in English, excepting in the books on bacteriology, where a brief mention is made of its discovery in Germany by Kuhn, and its description by Zopf.* An illustration after Zopf is copied into each of these books. This illustration represents all the modifications of filaments observed springing from a common base. This, of course, is diagrammatic. Zopf calls the Zooglœa palmella-like colonies. It is not unlikely that the cell masses of *Crenothrix* may have been confused with a species of *Palmella*, and

described as such; some such assumption is required to account for its having been for so long undiscovered, as it appears to be widely diffused. M. Alf. Giard has a paper in *Comptes Rendus* (Tome 95, 1882, pp. 247) briefly descriptive of a condition in the water at Lille similar to that I have been relating. M. Giard states that *Crenothrix* had at that date already given trouble in several other places, notably at Halle, Breslau, and Berlin. At Lille, the development occurred in the spring. On April 22nd, the water was unusable in certain quarters of the town, the growth manifesting itself in the reservoir and in certain parts of the pipes. This agrees with our experience. It is clear that the spore cocci have power of multiplying themselves in the pipes, as in certain parts of the town the water was worse affected than that contained in the tank receiving water direct from the filters; that seen in the school swimming bath, for instance, looked as bad or worse than the unfiltered water of the reservoir. But although the spores are evidently capable of reproducing themselves *per se* to a considerable extent, apart from their power of forming zooglœa and filaments, we may suppose it to be necessary to the ultimate continuation of the species that the vitality of the organism shall be renewed by passing through higher vegetative forms. In regard to the movement exhibited by the spore cocci, Giard writes:—"les microgonidies formées dans les sporanges ou extrémités renflées des tubes de *Crenothrix* sont animées d'un mouvement actif du à l'existence d'un flagellum." Zopf speaks of the halo surrounding the spores as a hyaline membrane.

The ability of the spore cocci to reproduce themselves, will account for their swarming in our reservoir, and for their reproduction in, at least, some portions of the pipes; in fact, the study of this visitation constitutes an object lesson in the ease with which a microbe may develop in the mains of a water service, and pollute a water which has been carefully filtered before being turned into the pipes. There are generally certain portions of the water pipes where the chance of such a development is greater than elsewhere. I refer particularly to "dead ends," or *cul de sacs*, where the water is liable to become stagnant. An intermittence in the supply of any part of the service possesses a similar disadvantage, by leading to the disturbance of any growth or deposit upon the pipes, which will then be washed through the house taps. By such considerations one might understand the possibility of some parts of a system of water supply being affected by a pathogenic bacterial growth, and other parts escaping.

It is probable that contact with bare iron or iron rust stimulated the growth, in particular portions of the pipes, and heightened the colour of the product. That the plant in all its phases can appropriate a small quantity of iron is undoubted,

* Entwicklungsgeschichtliche untersuchung über *Crenothrix polyspora* die ursache der Berliner Wassercalamität von Dr. W. Zopf. Berlin, 1879.

but the resulting colour, though a little suggestive of ferric oxide, is not due to any ordinary salt of iron as such, but is due to a proper pigment, which perhaps cannot be formed without iron, but which only requires a very small quantity for its elaboration. The thick fluid which drained from the dirty sand removed in the process of cleaning the filters, gave some interesting chemical reactions. Hydrochloric acid decolourised it after first turning it purplish and green. This mixture gave a very decided reaction for iron with potassium ferrocyanide. Strong nitric acid coagulated the red fluid, and the weak acid turned it a salmon-pink colour. Strong sulphuric acid added drop by drop produced a curious and characteristic effect. There was effervescence, and the brown-red colour of the fluid was changed first to a green-blue and afterwards to an intensely dark purple.

Strong caustic alkalis produced green coagula, but weak solutions of the same, and ammonia water formed a yellow turbid fluid, a great part of the colouring matter being taken into solution. Oil of turpentine, when the brown-red fluid was in sufficient quantity, turned it a beautiful purple pink colour; the colour was not dissolved out by the turpentine, but remained in the aqueous portion of the mixture; being occasionally shaken up with the turpentine, the colour faded through paler shades of pink, and was completely bleached after some days. Chlorine water bleached the brown-red fluid at once. The fluid was coagulated by alcohol and yielded no colour to it. It was immixible with chloroform or ether, repelling them as oil does water. It yielded part of its colour, however, to boiling chloroform. After first shaking the brown-red fluid with ammonia water, and then with chloroform, the pigment was dissolved out by the chloroform. Obtained in the dry condition it was an amorphous golden brown substance. It did not give the violet colour with oil of turpentine as did the original fluid. A drop of sulphuric acid, however, when dropped upon it in a porcelain evaporating dish, produced pink and peacock-blue colours. Upon washing off the acid with water, the yellow colour returned, and this operation could be repeated over and over again. The yellow pigment was totally insoluble in distilled water or weak acids, but readily dissolved by alcohol, ether, chloroform, benzine, oil of turpentine, ammonia water, and solutions of the fixed alkalis. It was entirely bleached after exposure for some days to the sunlight.

During the time the water was red the number of colonies obtained on a gelatine plate from 1 c.c. of the unfiltered water was about 5,000. The greater portion of these were colonies of the spore coccus. Ordinarily the number of colonies from 1 c.c. of the unfiltered water varies from 250 to 1,500.

The effect of the growth of the coccus on the quality

of the water, as estimated by ordinary chemical analysis, was a marked diminution of nitrate and an increase of nitrite. This also happened in a water polluted by another organism, about which I wrote some two or three years ago. The ammonia yielded by the water, both directly and on distillation with alkaline permanganate, was also largely increased. The water was insipid to the palate, being badly aerated. For some months prior to the redness in the water occurring the quality of the water, as supplied to the town, had not been up to a desirable standard, and new filters were at the time under construction, with a view to obtaining a better water by slower filtration. These additional filters are now completed and in use.

Although for many weeks during which it was affected the water from the Dowdeswell Reservoir continued to constitute the main supply to the town, and although there were many complaints of the odour, appearance, and unpalatability of the water, there was no evidence to prove that the organism, which was being consumed in great numbers, had any pathogenic influence. Apart from an epidemic of measles, which came to an abrupt end just when the water was at its worst, the general health of the town was as good as usual.

The growth and decay of microscopic or larger organisms in drinking water, as a source of pollution of such water, or what may be called the contamination of water by natural means, has received scant notice by writers of books and articles upon water supplies and water analysis. In fact, the only English publication in which I find the matter mentioned is the useful book recently published by Dr. J. C. Thresh on "Water and Water Supplies." The subject is, however, of considerable importance, and likely from time to time to lead to unexpected difficulties; and although in certain cases, as in that I have just recorded, there appears to be no direct danger, there is certainly no good, but always some unpleasantness.

The number of organisms which have been noticed as causing disagreeable odours, flavours, and general contamination of water, is growing considerable. In a paper in *PUBLIC HEALTH* for February, 1893, I wrote of an odour and pollution which occurred in a natural way in another set of reservoirs forming an auxiliary water supply for Cheltenham.

These, called the Hewlett's Reservoirs, are filled with spring water, which, as it is originally discharged to the reservoirs, is almost devoid of organic impurity. The comparatively large alga *Chara fatida* grows upon the sides of the brick-lined reservoirs, and, together with the parasites which feed upon its decaying substance, causes in the early autumn an unpleasant fishy odour and flavour in the water. The water at the same time becomes opalescent, by a diffusion through it of

numerous minute organisms, amongst which *Volvox globator* takes a chief place in point of numbers. Experience has shown that so sure as the reservoir is allowed to stand full during the summer months this trouble will arise in September, and the water have to be turned to waste when the general supply is at its lowest. In a covered reservoir receiving the same water no growth or pollution whatever occurred, showing that daylight is necessary for its development.

At the present time (September) the lake in Pittville Park, in this town, has its water turned to a blue-green colour, the water being also very turbid, and having a strong odour. Floating upon it in a few places is a scum of a bright glaucous green shade. This is very thick at the top end, and under the bridge where the brook comes in. Here it covers the water in patches some feet across, and the appearance is as if some bucketsful of green paint had been poured on to the water. The odour is that of a foul brook bottom; it can be smelt some short distance from the edge of the lake, and clings persistently to the hands and clothing if the latter happen to have been splashed with the water. The same phenomenon has occurred in this lake in previous years. Microscopic examination reveals the presence of two organisms as a cause of the colour and odour. The first is a species of *Anabaena*, of the Nostoc order, which occurs in myriads of moniliform trichomes, varying from $\frac{1}{600}$ to $\frac{1}{50}$ of an inch in length, and consisting of from four to fifty cells each, most of the threads having a medium length of from $\frac{1}{600}$ to $\frac{1}{75}$ inch. They are nearly straight, and float freely in the water, and are collected in the paint-like scum into matted masses. Associated with the *Anabaena* is a monad, which occurs in great numbers, is of a yellow-green colour, and moves rapidly about amongst the threads by means of flagella. If a bottle of the water be collected and allowed to stand some days, a paint-like rush-green scum rises to the surface like that seen on the lake; at the same time there is a deposit of a bile-green colour. The latter consists of the monads, the former of the *Anabaena* threads; a few other allied organisms, spores, etc., are also present.

In Hassall's "Fresh Water Algæ," some reference is made to the colouring of water in a similar way to the above. *Anabaena Spiralis* gave a blue-green colour to Ballydrain Lake, near Belfast; and an allied alga *Oscillatoria ærugescens* coloured Glaslough, also in the North of Ireland. Engelhardt and Freschel described a minute alga, which they named *Oscillatoria rubescens*, and which tinged with a red colour the Lake of Morat, in Switzerland. The water of the Red Sea is said to derive its name from the periodical development of *Trichodesmium Ehrenbergii*, and other parts of the ocean are known to be similarly coloured. Mr. W. Phillips, F.L.S., of Shrewsbury, sent me, some time ago, a paper on "The Breaking of the Shrop-

shire Meres," the word "breaking" being a local word to signify a seasonal change and colouration which occurs in the water. The water is coloured blue-green, and Mr. Phillips found several species of Nostocaceæ present with other organisms. In a Report to the Massachusetts State Board of Health, printed in the 1890 Vol. of the Examinations of the Board, Mr. G. H. Parker gives a list of fifteen organisms, which in his experience produce odour in water. In the Twenty-fourth Annual Report of the same Board, Mr. G. N. Calkins has "A Study of Odours Observed in the Drinking Waters of Massachusetts." Mr. Calkins says the principal odours may be described as vegetable, sweetish, aromatic, grassy, mouldy, fishy, disagreeable, offensive, musty, earthy. He gives a list of organisms which respectively produce odours as thus designated.

DESCRIPTION OF PLATE.

- a. The original cocci as contained in the red fluid from the sand, etc. b. The same fixed and stained. It is impossible to represent the exact appearance of the moving cocci. In both of these figures there are relatively too many masses and too few individual cocci.
- c. Cocci from a culture on Agar-agar jelly.
- d. Cocci from a culture on coagulated serum.
- e. Floccula in water from house tap, showing zoogloea, with a diatom in the centre.
- f. Floccula from unfiltered water, showing zoogloea tending to run into filaments.
- g. The dry froth from the reservoir.
- h. Zoogloea from the deposit on the water mains.
- i. The conversion of a mass of cells into a dense mesh-work of young filaments.
- j. A portion of the same at a higher magnification.
- k. Young filaments developed by putting the serum growth of froth into the water.
- l. Flocculent material from a carbon filter, showing zoogloear cells and filaments, and a few joints of a conferva.
- m. Flocculent deposit from water from house tap.
- n. The growth on the stones lining the reservoir. The central axis cylinder of the filaments is strongly stained and conspicuous.
- o. Modes of spore formation by division into and discharge of portions of the central axis cylinder from the filament.
- p. q. Mode of spore formation by disintegration of large filaments.

RECENT RESEARCH.

INTESTINAL DISINFECTION.

SOME interesting researches on this subject have been made by Dr. Louis Brotzu in the Institute of Hygiene of the University of Cagliari. He studied in the first place the influence of various kinds of diet on the number of micro-organisms in the intestine of the dog, and concluded that the