by the electrometer. We then tried 24, 48, 72, 96, 120 wire-gauze discs, successively, placed in groups of 24, and separated from one another by short lengths of 2 cm. of lead tube, in the line of the flow of the air between F and G (fig. 1), all kept in metallic connection with the block-tin pipe and the outer case of the electrometer. We were surprised with the smallness of the additions to the diselectrifying efficiency of the 12 strainers first tried; for example, the filter of 120 wire gauzes only reduced the electrical indication to a little less than one-half of what it was with the 12 which we first tried.

We found that cotton-wool between the spaces in the groups of 24 wire gauzes largely increased the diselectrifying effect. Thus, with 72 wire gauzes and cotton-wool we succeeded in reducing the electrical effect to about one-twelfth of what it was with only a filter of 12 wire gauzes; but hitherto we have not succeeded in rendering imperceptibly small the electricity yielded by the outflowing air to the testing filter R in our method of observation.

§ 6. We intend trying various methods of obtaining more and more nearly complete diselectrification of the electrified air flowing out of the can at F; and this for air electrified otherwise than by the needle point, as shown in the diagram: for instance, by an electrified flame in place of the needle point; or again by bubbling through water or other liquids. Meantime, the mere fact that the electricity, whether positive or negative, given to air by an electrified needle point, can be conveyed through 3 or 4 metres of small metal tube (1 cm. diameter), and shown on a quadrant electrometer by a receiving filter, is not without interest. We may add now that, with the receiving filter removed and merely a fine platinum wire put in the mouth of the paraffin tunnel, we have found that enough of electricity is taken from the outflowing air to be amply shown by the quadrant electrometer; which renders even more surprising the fact that the diselectrifying power of 120 strainers of fine wire-gauze should be so small as we have found it.

II. "On the Conditions affecting Bacterial Life in Thames Water." By E. FRANKLAND, D.C.L., F.R.S. Received January 31, 1895.

Since May, 1892, I have been making monthly determinations of the number of bacteria capable of development on a peptone-gelatine plate in a given volume of Thames water collected at the intakes of the Metropolitan water companies at Hampton. The number of microbes per cubic centimetre of water varied during this time between 631 and 56,630, the highest numbers having, as a rule, been

found in winter or when the temperature of the water was low, and the lowest in summer or when the temperature was high.

Amongst the conditions which favour or retard the development of microbial life in river water, temperature, rainfall, and sunshine or gloom are probably the most important, sunshine having been recently shown by Dr. Marshall Ward to be, under certain circumstances, extremely potent in the destruction of bacteria. The following tables contain the results of these microbe determinations placed in juxtaposition with (A) the temperature of the water at the time the sample was taken, (B) the number of hours of sunshine on the day and up to the hour when the sample was drawn and on the two preceding days, and (C) the flow of the Thames over Teddington Weir on the same day expressed in millions of gallons per 24 hours.

The samples for microbe cultivation were collected at about 9 in. below the surface of the water in partially exhausted and sealed tubes, the ends of which, when the tubes were lowered to the desired depth, were broken off by an ingenious contrivance devised by my assistant, Mr. W. T. Burgess. On being withdrawn from the river, the tubes were immediately hermetically sealed and packed in ice for conveyance to my laboratory, where the cultivation was always commenced within four hours of the time of collection.

For the records of sunshine I am indebted to the kindness of Professor E. J. Stone, M.A., F.R.S., the Radcliffe Observer at Oxford, and to Mr. James B. Jordan, of Staines. Finding that the Oxford observations differed but little from those at Staines, and as Staines is nearer to, although higher up, the river than the place where my samples were collected, I have used the Staines records in the table, except on a few dates when Mr. Jordan's observations had been intermitted.

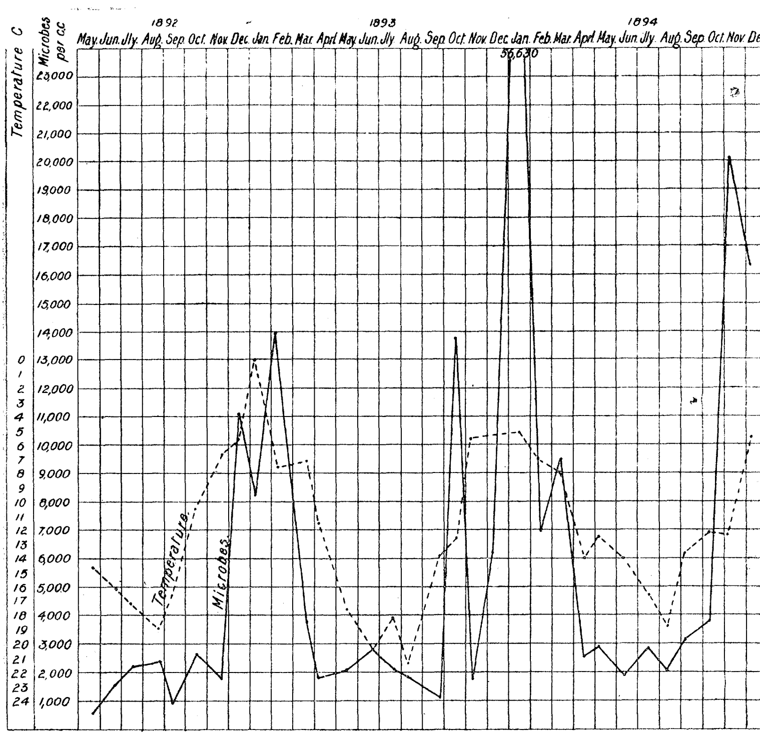
The gaugings of the Thames at Teddington Weir were kindly furnished by Mr. C. J. More, the engineer to the Thames Conservancy Board.

Without the data giving the conditions of sunshine and flow of the river, it was impossible to draw any trustworthy conclusion as to the cause of the increase and diminution of the number of microbes per cubic centimetre of Thames water at Hampton, because the conditions supposed to be favourable for microbial life all, approximately, attain the greatest intensity at the same season of the year; thus, whilst the temperature is lowest in winter, so also, as a rule, are the minimum amount of sunshine and the maximum amount of flood water. The following collateral observations, however, afford definite evidence as to which of the three conditions—temperature, sunshine, and flow of the river—has the predominant influence upon bacterial life in the water. The first table and diagram compare the

Table A.—Comparison of Number of Microbes with the Temperature of Thames Water.

Date.	Temperature, C.	Number of microbes per c.c.	Date.	Temperature, C.	Number of microbes per c.c.
1892.			1893.		
May 20	14·8°	631	September 25	13·8°	1,158
June 20	16·2	1,658	October 19	12·5	13,790
July 13	17·2	2,268	November 9	5·6	1,789
August 25	19·1	2,421	December 7	5·4	6,316
September 12	16·6	947			
October 17	10·5	2,316	1894.		
November 22	6·7	1,868	January 15	5·2	56,630
December 15	5·6	11,158	February 13	6·9	6,947
			March 13	8·0	9,480
1893.			April 13	14·0	2,520
January 9	0	8,210	May 3	12·5	2,880
February 4	7·6	13,947	June 11	14·1	1,840
March 20	7·2	3,737	July 16	16·7	2,860
April 5	11·6	1,763	August 11	18·7	2,080
May 16	17·6	2,052	September 7	13·8	3,080
June 20	20·4	2,789	October 10	12·2	3,800
July 19	18·2	2,132	November 5	12·3	20,080
August 10	21·3	1,895	December 10	5·5	16,300

DIAGRAM No. 1.



number of microbes per cubic centimetre with the temperature of the water at the time the samples were taken. In this diagram the ordinates express the numbers of microbes and the temperatures, whilst the abscissæ denote the months when the samples were taken. For obvious reasons the ordinates expressing numbers of microbes and temperature are numbered in opposite directions.

From this table and diagram, high temperature would appear to have been unfavourable to microbes in May, June, July, August, and September, 1892, when the number per cubic centimetre was small; but in October and November the number still remained small, although the temperature in these months was much lower. In December, however, of the same year the temperature remained much the same as in November, but the microbes underwent an enormous increase. Again, in the following year (1893), the temperature in January on the day when the sample was collected was still lower, being at the freezing point, but the microbes were considerably less numerous. On the other hand, in February, when the temperature was higher,

the microbes were much more numerous than even in the previous December. In March, whilst the temperature remained practically the same as in February, the number of microbes per cubic centimetre fell from about 14,000 to about 3,700. Again, in April, whilst the temperature was still moderate (11·6° C.), the number of microbes fell still further to less than 2,000 per cubic centimetre. In May, June, July, and August, the temperature was high and the number of microbes uniformly small, but in September there was a great reduction of temperature, but accompanied also by a considerable diminution in the number of microbes. In October there was again, as in February, an enormous development of bacteria whilst the temperature was only slightly lower than in the previous month, when the number was remarkably small. In November again, with a much lower temperature, there was a reduction in the number of microbes from about 14,000 in the previous month to about 1,750 per cubic centimetre. During the following months of November and December, 1893, and January, February, and March, 1894, whilst the temperature remained low and nearly constant, the microbes were sometimes as low as 1,789, and sometimes as high as 56,630; but, during the following months—April, May, June, July, August, September, and October—the increase of temperature and diminution of microbes, and *vice versâ*, marched very much *pari passu*. In November, however, with no alteration of temperature as compared with the previous month, the number of microbes increased from 3,800 to 20,080 per cubic centimetre, whilst in December there was a diminution alike in temperature and microbes.

Thus it is evident that, although coincidences between a high number of microbes and a low temperature are not wanting, some other condition entirely masks the effect of temperature.

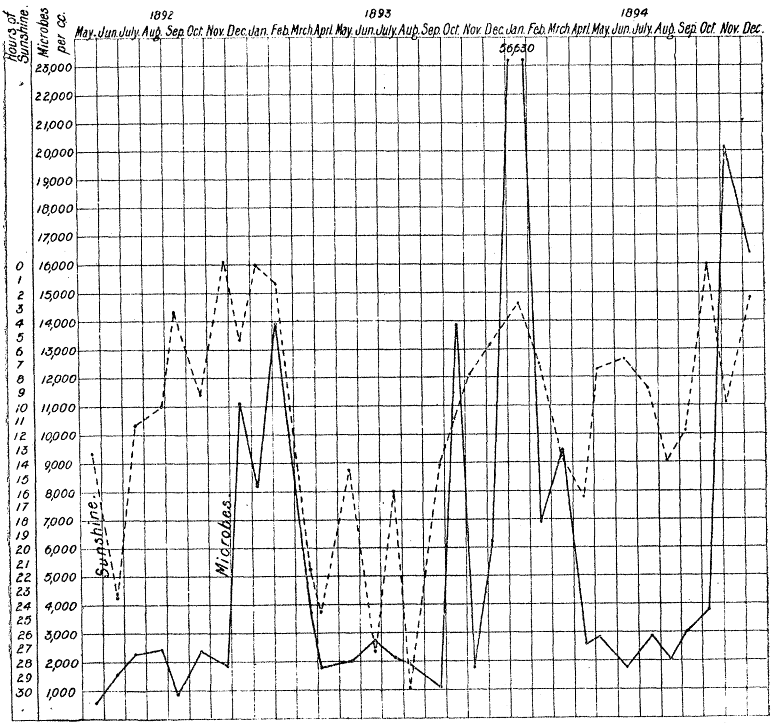
The next table and diagram institute a comparison between the number of microbes and the hours of sunshine to which the water has been exposed. The diagram is constructed on the same lines as No. 1.

Reference to the table and diagram shows that, whilst during the months May to November, 1892, there was an enormous variation in the amount of sunshine, namely, from 23½ hours in June to none in November, there was practically no corresponding variation in the number of microbes. In December of that year, there was much more sunshine than in the previous month, but the microbes, instead of being diminished thereby, increased from less than 2,000 to over 11,000 per cubic centimetre; and, although there was no sunshine on the three days previous to the taking of the sample in January, 1893, the number of microbes actually decreased about 3,000 per cubic centimetre. In the following month of February, however, about 14,000 microbes per cubic centimetre coincided with but little

Table B.—Comparison of Number of Microbes with Hours of Sunshine.

Date.	Hours of sunshine during 3 days at Staines.	Number of microbes per c.c.
1892.	h. m.	
May 20	13 10	631
June 20	23 30	1,658
July 13	11 10	2,268
August 25	9 55	2,421
September 12	3 15	947
October 17	9 15	2,316
November 22	0	1,868
December 15	5 20	11,158
1893.		
January 9	0	8,210
February 4	1 20	13,947
March 20	21 30	3,737
April 5	24 30	1,763
May 16	14 30	2,052
June 20	27 25	2,789
July 19	15 55	2,132
August 10	29 55	1,895
1893.	h. m.	
September 25	14 5	1,158
October 19	11 5	13,790
November 9	7 45	1,789
December 7	5 45	6,316
1894.		
January 15	2 45	56,630
February 13	7 0	6,947
March 13	13 40	9,480
April 13	16 20	2,520
May 3	7 30	2,880
June 11	6 35	1,840
July 16	8 45	2,860
August 11	13 55	2,080
September 7	11 50	3,080
October 10	0	3,800
November 5	9 50	20,080
December 10	2 15	16,300

DIAGRAM No. 2.



more than an hour of sunshine. In the following month of March again, an enormous increase of sunshine was followed by a corresponding decrease of microbes, and this relation was continued in the following month; but in May, with a great diminution of sunlight, there was practically no increase of microbes, and in June, with an enormous increase of sunlight, there was the anomaly of an increase, though slight, of bacteria.

In the following July and August, there were enormous alternations of sunshine and gloom with no corresponding difference in the number of microbes; whilst in September, with a great diminution in sunshine, there was observed one of the smallest numbers of microbes recorded. In the following month of October, however, a small diminution of sunshine was accompanied by a very large increase of microbes. On the other hand, in the month of November, with a still smaller amount of sunshine there was an enormous reduction in the number of microbes.

In January, 1894, a small amount of sunshine was followed by an

enormous number (56,630) of microbes. In the following month of February, however, this number was reduced to about 7,000, although the amount of sunshine was not very much greater. In the following month of March, there was a great increase both of sunshine and bacteria, whilst in April, there was an increase of sunshine and a great diminution in the number of microbes. In May, however, there was a great decrease of sunshine, but a very slight increase of microbes. In June there was rather less sunshine than in the previous month, but also fewer microbes; whilst in July, an increase of sunlight was accompaned by an increase of microbes. In August, September, and October, with each diminution of sunshine there was a corresponding increase of microbes; but in November, with a very moderate amount of sunlight, there was an enormous increase of microbes from 3,800 to 20,080 per cubic centimetre, whilst in the following month of December a considerable diminution of sunlight was found to be compatible with a marked decrease of microbes.

Thus it is evident that, as in the case of temperature, there is some other condition which entirely overbears the influence of sunlight in the destruction of microbes in the river water. This condition is the amount of rainfall higher up the river, or, in other words, the volume of water flowing along the river bed, as is seen from the comparison presented in the following table and diagram (pp. 447, 448).

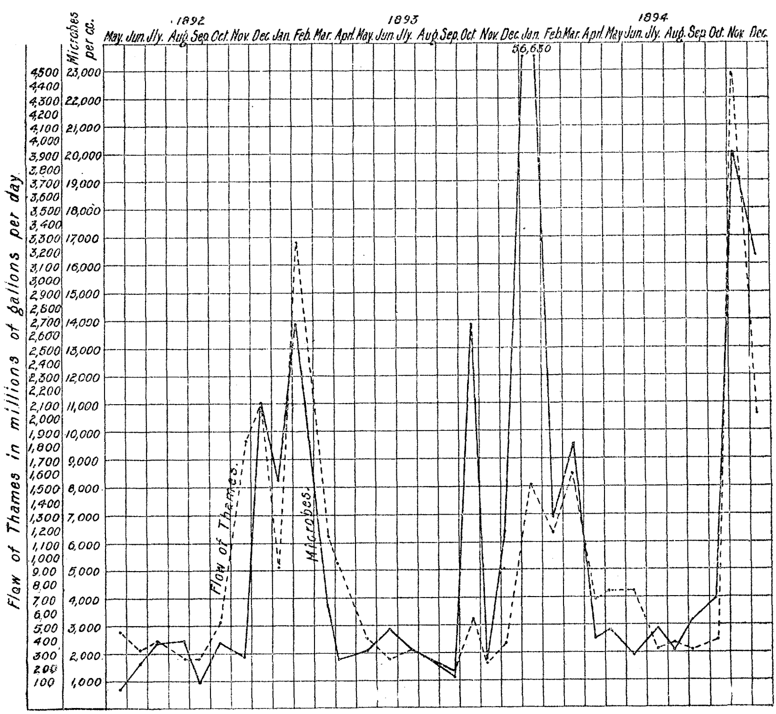
This table and diagram show very conclusively that the volume of water flowing in the Thames is the paramount influence determining the number of microbes in the water. They compare the volume of water in the river, as gauged at Teddington Weir, with the number of microbes found in the raw Thames water at Hampton on the same day. In the diagram, the numbers representing the flow of the river in millions of gallons and the number of microbes per cubic centimetre of water both run from the bottom of the diagram upwards.

Comparing the numbers in the table and the curves on the diagram, it is seen that, with a few exceptions, a remarkably close relation is maintained between these numbers and curves respectively; thus during the months of May, June, July, August, September, and October, 1892, the river was low and the number of microbes small. In December of the same year, the daily flow of the river had risen to 2,105 millons of gallons, and the microbes to 11,158 per cubic centimetre; whilst in January 1893, the flow had decreased to 915 millions of gallons, and the microbes to 8,210 per cubic centimetre. In February of the same year, the flow of water over Teddington Weir had risen to 3,255 millions of gallons, and the number of microbes simultaneously to 13,947 per cubic centimetre; whilst in March, with a reduced flow of 1,175 millions of gallons, the number of microbes came down to 3,737 per cubic centimetre, and this was followed in April by a further diminution to 1,763 per cubic centimetre, whilst

Table C.—Comparison of Number of Microbes with Rate of Flow of River on same Day.

Date.	Daily flow of river.	No. of microbes per c.c.
1892.	Gallons.	
May 20	480,000,000	631
June 20	335,000,000	1,658
July 13	385,200,000	2,268
August 25	276,300,000	2,421
September 12	270,000,000	947
October 17	501,300,000	2,316
November 22	1,845,000,000	1,868
December 15	2,105,000,000	11,158
1893.		
January 9	915,000,000	8,210
February 4	3,255,000,000	13,947
March 20	1,175,000,000	3,737
April 5	985,000,000	1,763
May 16	420,000,000	2,052
June 20	277,200,000	2,789
July 19	333,000,000	2,132
August 10	264,600,000	1,895
1893.	Gallons.	
September 25	159,300,000	1,158
October 19	542,700,000	13,790
November 9	249,300,000	1,789
December 7	375,000,000	6,316
1894.		
January 15	1,510,000,000	56,630
February 13	1,140,000,000	6,947
March 13	1,600,000,000	9,480
April 13	690,000,000	2,520
May 3	740,700,000	2,880
June 11	745,200,000	1,840
July 16	369,900,000	2,860
August 11	360,900,000	2,080
September 7	336,600,000	3,080
October 10	396,000,000	3,800
November 5	4,462,200,000	20,080
December 10	2,058,300,000	16,300

DIAGRAM No. 3.



the flow of the river was simultaneously reduced to 985 millions of gallons daily.

In the following months, May, June, July, August, and September, the river remained low, and so did the number of microbes; but in October, with an increase of flow from 159 to 543 millions of gallons, the number of microbes increased from 1,158 to 13,790 per cubic centimetre; whilst, in the following month of November, the flow of the river was reduced to 249 millions of gallons and the microbes to 1,789 per cubic centimetre. Again, in the following month of December, the flow of the river increased to 375 millions of gallons, and the microbes to 6,316 per cubic centimetre.

In January, 1894, the flow of the river was augmented to 1,510 millions of gallons, and the microbes to the enormous number of 56,630 per cubic centimetre. In the following months of February, March, April, and May, the two curves follow each other with remarkable regularity; whilst in July, August, September, and October, both the flow of the river and the number of microbes remained low, there being a slight increase in both from September to October.

Then came the tremendous flood of November, the highest on record, the flow of the river over Teddington Weir, on the 18th, having reached nearly 20,136 millions of gallons. The sample for microbe cultivation was, however, taken on the 5th, when the flow only amounted to 4,462 millions of gallons per day, but this increase from 396 millions of gallons in October to 4,462 millions on the 5th of November was accompanied by an increase in the number of microbes from 3,800 on the 10th of October to 20,080 per cubic centimetre on the 5th of November; whilst, in December, the flow of the river had fallen to 2,058 millions of gallons per day, and the number of microbes to 16,300 per cubic centimetre.

The only exception of any importance to the rule, that the number of microbes varies with the flow of the river, occurring during the thirty-two months through which these observations have been continued, happened in November, 1892, when the flow increased from 501 millions of gallons in October to 1,845 millions in November, whilst the microbes actually diminished in number from 2,316 to 1,868 per cubic centimetre. Neither the sunshine nor the temperature records of these two months, however, afford any explanation of this anomalous result, for there was a good deal of sunshine in October before the collection of the sample, and the temperature was higher; whilst in November, no ray of sunshine reached the Thames during the three days preceding the taking of the sample, and the temperature was nearly 4° C. lower than in the preceding month.

These comparisons, therefore, demonstrate, I think satisfactorily, that the number of microbes in Thames water depends upon the rate of flow of the river or, in other words, upon the rainfall, and but slightly, if at all, upon either the presence or absence of sunshine or a high or low temperature.

With regard to the effect of sunshine upon bacterial life, the interesting researches of Dr. Marshall Ward leave no doubt that sunlight is a powerful germicide; but it is probable that its potency, in this respect, is greatly diminished if not entirely annulled, when the solar rays have to pass through a stratum of water even of comparatively small thickness before they reach the living organisms. If this be the case, it can be no matter for surprise that the effect of sunshine upon bacterial life in the great mass of Thames water should be nearly, if not quite, imperceptible.

Note added March 16.

Since this paper was written, I have ascertained that between October 17 and November 22, 1892, when the sample for microbe cultivation was collected, the river had several times been in such high flood as to be bank-full. Thus, between October 30 and

November 2, the flow was never less than 3,000 millions of gallons per day, and on November 2 it reached 4,240 millions. Again, on the 17th the flow was 3,305 millions, and on the 18th, 4,165 millions. It then gradually decreased to 1,845 millions on the day when the sample was drawn. Thus the Thames basin had been twice very thoroughly washed out immediately before the time when the November sample was taken. There had previously been no such floods after the 5th of January in that year. This condition of things affords a fairly satisfactory explanation of the anomalous result yielded by this sample.

III. "The Cause of Luminosity in the Flames of Hydrocarbon Gases." By VIVIAN B. LEWES, Professor of Chemistry at the Royal Naval College, Greenwich. Communicated by Professor THORPE, F.R.S. Received February 14, 1895.

In a paper read before the Chemical Society in 1893, I showed that in the inner non-luminous zone of a flame of ordinary illuminating gas, the hydrocarbons originally present in the gas, and consisting of ethylene, butylene, benzene, methane, and ethane, became converted by the baking action of the walls of flame between which they had to pass into acetylene, and that at the moment when luminosity commenced, over 80 per cent. of the total unsaturated hydrocarbons present consisted of this compound.

The presence of acetylene at the point where luminosity commenced naturally suggested that it was in some way due to actions in which the acetylene played the principal part—either that it split up into carbon and hydrogen under the influence of heat, and so supplied the flame with the solid particles necessary, according to Sir Humphry Davy's theory of the cause of luminosity, or else by its polymerisation it formed the dense vapours required by Dr. E. Frankland's more recent hypothesis.

In order to elucidate this point, I carried out the long series of experiments upon the action of heat upon flowing ethylene and other hydrocarbons, which formed the subject of communications to the Royal Society in 1893 and early this year, in which I showed that whilst flowing through a heated area (the temperature of which was between 800° and 1000° C.), ethylene decomposed according to the equation

$$3C_2H_4 = 2C_2H_2 + 2CH_4,$$

and that the acetylene then polymerised into a large number of more complex hydrocarbons, amongst which benzene and naphthalene were conspicuous, whilst at temperatures above 1200° C., no polymerisation