XIII. *Contributions to the Chemistry of the Urine.*—Paper III.

PART I. *On the Variations of the Acidity of the Urine in the state of Health.*

PART II. *On the simultaneous Variations of the amount of Uric Acid, and the Acidity of the Urine in the state of Health.*

PART III. *On the Variations of the Sulphates in the state of Health, and on the influence of Sulphuric Acid, Sulphur and Sulphates, on the amount of Sulphates in the Urine.*

By HENRY BENCE JONES, *M.D., M.A. Cantab., F.R.S., Physician to St. George's Hospital.*

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PART I.—*On the Variations of the Acidity of the Urine in the state of Health.*

IN the Philosophical Transactions for 1845, I showed that not unfrequently in London, the urine was found in many persons to be alkaline from fixed alkali; and I mentioned that Dr. ANDREWS, at Belfast, had found the water passed at noon of two-thirds of the students of his class to be alkaline.

It appeared to me to be a matter of great interest to determine quantitatively the daily variations in the acidity and alkalescence of the urine in the state of health; to trace, if possible, the cause of the variations; to determine the effect of some medicines; at the least until this was done I could draw no conclusions regarding the effect of diseases on the acidity of the urine.

In examining quantitatively the variations at different hours of the day, it was immediately found that there was no fixed degree of acidity of the urine; that the acidity did not vary with the specific gravity, but that there was a never-ceasing change, an ebb and flow, in the acid reaction of the urine, which was quite independent of the specific gravity.

The degree of acidity of the urine was found generally to be greatest a short time before food was taken; and after food the acidity was diminished, until about three hours after breakfast, and four or five, or six hours after dinner, when it reached the minimum point; after which it again rose and attained its height previous to food being again taken.

A healthy man was the subject of the following experiments: for three months he had taken strong exercise, walking above 700 miles. Food was taken twice daily. The exercise was moderate during the experiments, from three to four hours daily.

The urine not unfrequently showed most marked alkalescence from fixed alkali. Rarely even phosphate of lime was deposited. Five or six hours afterwards the

acidity reached its highest point, but did not on any occasion cause the formation of uric acid crystals.

The mode of examination was the following. Two test solutions were made, the one with carbonate of soda, the other with dilute sulphuric acid. Each measure of either test was made equivalent to $\frac{1}{12}$th of a grain of dry and pure carbonate of soda.

A bottle containing 1000 grains at least of urine was filled and weighed. The urine was heated in a cup to 120°, and then the test solution was dropped in from a graduated tube; so that the urine, when acid, was made, by alkali, just neutral to the most delicate test-paper; and when alkaline, it was made just neutral by acid. The number of measures required gave the degree of acidity or alkalescence of the urine.

In the second part of this paper, it will be seen from experiments made four months previously to these, that the same kind of variations took place then; and in the same case two years before, and again even three years previous to these experiments, the same fact was noted.

Thus, October 13, 1846, breakfast on bread and meat at 9 A.M.

Urine passed at 1 P.M., clear. Specific gravity . . 1022·8. Alkaline.
Urine passed at 3 P.M., clear. Specific gravity . . 1019·9. Acid.

And October 28, 1845, breakfast at $9^h\ 15^m$.

	h	m		
Urine passed at	10		A.M.	Acid.
Urine passed at	12	30	P.M.	Alkaline.
Urine passed at	3			Acid.

(1.) October 14, 1848. Breakfast on bread, meat and coffee, at $8^h\ 45^m$ A.M. Dinner at $5^h\ 50^m$ P.M. Fish, meat, potatoes and water.

	h	m		Spec. gr.	Acidity per 1000 grs. of urine.	Appearances.
Water passed at	7	15	A.M.	thrown away.		
Water passed at	8	45		=1021·1	+11·75 measures.	Clear.
Water passed at	9	55		=1023·5	+ 8·79	Clear.
Water passed at	11	15		=1022·7	−11·73	Clear.
Water passed at	12			=1024·4	−29·28	Thick from phosphates.
Water passed at	12	50	P.M.	=1024·0	−10·74	Clear.
Water passed at	2	15		=1021·5	+ 6·85	Clear.
Water passed at	3	50		=1024·1	+15·62	Clear.
Water passed at	5	50		=1024·4	+21·47	Clear.
Water passed at	7	55		=1029·6	+15·54	Thick from urates.
Water passed at	10	45		=1029·8	− 5·82	Clear.
Water passed at	6	30	A.M.	=1023·3	+ 9·77	Clear.
Water passed at	7	40		=1025·3	+13·65	Clear.

(2.) Breakfast at $8^h\ 45^m$ A.M., the same as the day previous. Dinner the same, at $5^h\ 45^m$ P.M.

Water passed at	8	45	=1025·6	+15·60 measures.	Clear.
Water passed at	10		=1021·3	+11·74	Clear.

	h	m	Spec. gr.	Acidity per 1000 grs. of urine.	Appearances.
Water passed at	11	20 A.M.	=1024·9	−12·68 measures.	Clear.
Water passed at	12	20 P.M.	=1029·2	−14·57	Thick from phosphates.
Water passed at	12	45			Clear.
Water passed at	3	15	=1028·4	+13·61	Clear.
Water passed at	5	45	=1026·6	+22·40	Clear.
Water passed at	9		=1032·9	+13·55	Thick from urates.
Water passed at	11	10	=1030·4	+ 3·88	Clear.
Water passed at	2	30 A.M.	=1011·4	+ 5·93	Clear.
Water passed at	7	30	=1020·6	+11·75	Clear.

(3.) Breakfast at $8^h\ 45^m$ A.M., the same as the day previous. Dinner at $5^h\ 5^m$ P.M.

Water passed at	8	45	=1024·8	+19·51 measures.	Thick urates.
Water passed at	9	50	=1020·6	+12·73	Clear.
Water passed at	10	50	=1021·8	+ 1·95	Clear.
Water passed at	12	50 P.M.	=1027·2	− 1·94	Clear.
Water passed at	2	50	=1024·7	+10·73	Clear.
Water passed at	5	5	=1024·9	+18·53	Clear.
Water passed at	7	35	=1029·2	+15·54	Thick from urates.
Water passed at	10	5	=1027·2	− 7·78	Clear.
Water passed at	2	15 A.M.	=1022·0	+ 8·80	Clear.
Water passed at	6	45	=1024·6	+16·59	Clear.
Water passed at	7	45	=1024·8	+20·49	Thick from urates.
Water passed at	8	45	=1022·5	+13·69	Clear.

From these experiments, which lasted three days, it appears that before each meal the urine showed the highest degree of acidity; and the water passed two or three hours after food always showed a lower degree of acidity than that made before food. The decrease continued until three hours after breakfast, and five or six hours after dinner, when it reached the lowest point. The acidity of the urine then increased until just before food, when it again reached the highest limit.

Thus, when breakfast was taken at half-past eight, the acidity of 1000 grains of the urine then passed was sufficient to neutralize about one grain of dry and pure carbonate of soda. At twelve o'clock the urine was as alkaline as if every 1000 grains of urine contained two and a half grains of carbonate of soda. At half-past five, just before dinner, the acidity had increased, so that every 1000 grains of urine was so acid as to require two grains of carbonate of soda to neutralize it. At half-past ten the acidity had diminished, so that every 1000 grains of urine was as alkaline as if they contained half a grain of carbonate of soda. After this it probably became more alkaline, and then still longer after food became acid; and by half-past eight in the morning, each 1000 grains of urine required about a grain and one-third of carbonate of soda to neutralize the acid reaction.

The same changes were observed on each of the two following days. These varia-

tions are seen in the accompanying Plate XVI. better than they can be set forth in words, and the influence of digestion on the acidity of the urine is made evident.

There is a slight exception which requires notice. In the last day, before breakfast, at $6^h\ 45^m$ A.M., the specific gravity was 1024·6, and every 1000 grains had an acidity marked by 16·59 measures. At $7^h\ 45^m$ P.M. the acidity had increased to 20·45, the specific gravity having hardly changed. At $8^h\ 45^m$ A.M., just before breakfast, the acidity had decreased to 13·69, with a very slight diminution of the specific gravity.

As a test of the truth of the conclusions drawn from the previous experiments, the variations of the acidity were noted when no food was taken in the morning, and the following results were obtained.

(4.) No food was taken from dinner the previous day at $5^h\ 30^m$ P.M., to dinner this day at $5^h\ 10^m$ P.M. Both days the food was meat, soup, potatoes, bread and water. The urine was passed as frequently as possible.

	h	m		Spec. gr.	Acidity per 1000 grs. of urine.	
Water passed at	6	10	A.M.	1025·7	+15·59 measures.	Clear.
Water passed at	7	50	No breakfast.	1028·6	+13·61	Thick from urates.
Water passed at	9	10		1026·3	+15·58	Thick from urates.
Water passed at	11	20		1025·0	+12·68	Thick from urates.
Water passed at	12	30	P.M.	1025·7	+13·64	Thick from urates.
Water passed at	2	45		1028·0	+15·56	Thick from urates.
Water passed at	5	10	Dinner.	1031·3	+15·51	Thick from urates.
Water passed at	7	10		1034·6	+13·53	Thick from urates.
Water passed at	9	5		1029·4	− 7·77	Clear.
Water passed at	11			1029·5	− 2 91	Clear.
Water passed at	5	40	A.M.	1026·9	+10·71	Clear.
Water passed at	8	45	Breakfast.	1028·0	+17·51	Thick from urates.
Water passed at	10	15		1026·3	+ 9·74	Thick from urates.
Water passed at	12	30	P.M.	1028·7	−14·57	Thick from phosphates.
Water passed at	3	10		1028·8	− 0·97	Clear.

Plate XVII. shows these variations, and contrasts the slight changes when breakfast was not taken, with the great changes after food.

From six in the morning until dinner was taken, soon after five, the variations in the acidity of the urine were very small; requiring rather more than one grain of carbonate of soda to neutralize 1000 grains of the urine. Four hours after dinner the urine was so diminished in acidity, that every 1000 grains of urine had an alkaline reaction equal to two-thirds of a grain of dry and pure carbonate of soda. Two hours after this the acidity was found to be increased, and by breakfast time, the following morning, 1000 grains of urine required a grain and a half of carbonate of soda to neutralize their acidity. Four hours after breakfast the acidity had decreased so much, that 1000 grains of urine were as alkaline as if they had contained nearly a grain and a quarter of carbonate of soda.

II. I next endeavoured to determine whether different kinds of food caused different changes in the acidity of the urine. For three days consecutively animal food only was taken at $8^h\ 45^m$ A.M. and $5^h\ 40^m$ P.M. Beefsteaks, eggs, weak coffee, milk and water.

	h	m		Spec. gr.	Acidity per 1000 grs. of urine.	
(5.) Water passed at	7	0	A.M.	thrown away.		
Water passed at	8	45		1024·6	+ 7·80 measures.	Clear.
Water passed at	9	50		1019·9	− 7·84	Clear.
Water passed at	10	55		1020·2	−30·38	Thick from phosphates.
Water passed at	12	55	P.M.	1025·2	− 9·73	Clear.
Water passed at	3	0		1027·0	+13·63	Thick from urates.
Water passed at	5	40		1029·5	+19·42	Thick from urates.
Water passed at	8	5		1032·8	+14·52	Thick from urates.
Water passed at	10	30		1030·3	0	Thick from urates.
Water passed at	5	0	A.M.	1022·9	+10·75	Clear.
Water passed at	7	10		1026·1	+17·52	Clear.

(6.) Breakfast at $8^h\ 50^m$ A.M. Dinner at $5^h\ 40^m$ P.M. Animal food only; the same as the previous day.

Water passed at	8	50		1026·7	+10·71 measures.	Clear.
Water passed at	10	10		1025·3	+ 1·95	Clear.
Water passed at	11	10		1024·6	−26·35	Thickish from phosphates.
Water passed at	12	30	P.M.	1025·3	−29·26	Thick from phosphates.
Water passed at	1	50		1025·5	− 1·95	Clear.
Water passed at	3	30		1025·0	+ 9·75	Clear.
Water passed at	5	40		1027·4	+17·52	Clear.
Water passed at	7	40		1031·7	+11·63	Thick from urates.
Water passed at	11	0		1028·7	− 2·91	Clear.
Water passed at	7	15	A.M.	1024·6	+13·66	Clear.

(7.) Breakfast at $8^h\ 50^m$ A.M. Dinner at $5^h\ 50^m$ P.M. Animal food only; the same as the previous day.

Water passed at	8	50		1027·0	+15·58 measures.	Thick from urates.
Water passed at	10	8		1026·5	+ 1·94	Cloudy.
Water passed at	11	10		1026·9	−24·34	Thick from phosphates.
Water passed at	12	10	P.M.	1029·8	−26·21	Thick from phosphates.
Water passed at	2	15		1025·2	+ 3·90	Cloudy.
Water passed at	3	40		1028·1	+13·61	Cloudy.
Water passed at	5	55		1029·7	+18·45	Cloudy.
Water passed at	7	55		1035·4	+16·41	Thick.
Water passed at	10	55		1031·7	+ 2·90	Thick.
Water passed at	6	0	A.M.	1026·0	+12·67	Clear.
Water passed at	7	40		1028·6	+18·46	Thick.
Water passed at	8	55		1028·7	+20·41	Thick.

From the comparison of these numbers, as seen in Plate XVIII., with those obtained when a mixed diet was taken, as in Plate XVI., it is apparent,—

1st. That the diminution of the acidity after food is more marked, and continues longer when animal food only is taken, than it does when mixed diet is eaten.

2nd. That the acidity before food rises rather higher with a mixed diet than it does with animal food only.

There is the same exception observable on the second day of animal food as was seen the third day when mixed diet was taken. At ten minutes after seven the urine had an acidity for every 1000 grains marked by 17·52 measures. At fifty minutes after eight (just before breakfast) the acidity was diminished to 10·71 measures. There was but little difference in the specific gravity of the two quantities.

For three days consecutively vegetable food only was taken, twice each day. Breakfast at $8^h\ 55^m$ A.M. Dinner at $6^h\ 15^m$ P.M.

	h m	Spec. gr.	Acidity per 1000 grs. of urine.	
(8.) Water passed at	8 55 A.M.	1028·7	+20·41 measures.	Thick from urates.
Water passed at	10 20	1028·0	+12·64	Thick.
Water passed at	11 40	1027·5	+ 7·78	Thick.
Water passed at	1 0 P.M.	1028·4	+ 7·78	Thick.
Water passed at	2 55	1027·8	+ 8·75	Thick.
Water passed at	6 15	1031·5	+20·36	Thick.
Water passed at	8 20	1036·4	+15·43	Thick.
Water passed at	11 5	1035·3	+16·42	Thick.
Water passed at	3 30 A.M.	1030·1	+12·62	Thick.
Water passed at	7 30	1030·1	+20·38	Thick.

(9.) Breakfast at $8^h\ 50^m$ A.M. Dinner at $5^h\ 35^m$ P.M. Vegetable food only.

Water passed at	8 50	1031·2	+26·18 measures.	Thick.
Water passed at	10 30	1029·4	+ 5·83	Thick.
Water passed at	12 0	1028·9	0	Clear.
Water passed at	2 10 P.M.	1027·8	+ 2·91	Clear.
Water passed at	5 35	1028·5	+16·52	Thick.
Water passed at	8 35	1034·2	+11·60	Thick.
Water passed at	11 45	1012·4	+ 1·97	Clear.
Water passed at	6 45 A.M.	1009·1	+ 5·94	Clear.
Water passed at	8 55	1020·5	+14·69	Clear.

(10.) Breakfast at $8^h\ 55^m$ A.M. Dinner at $5^h\ 55^m$ P.M. Vegetable food only. At breakfast about two ounces of honey were taken.

Water passed at	10 0	1013·5	+ 7·89 measures.	Clear.
Water passed at	10 35	1009·1	+ 4·95	Clear.
Water passed at	11 30	1018·9	+ 4·90	Clear.
Water passed at	12 50 P.M.	1020·8	+ 5·87	Clear.
Water passed at	2 10	1017·9	+ 6·87	Clear.

	h	m		Spec. gr.	Acidity per 1000 grs. of urine.	
Water passed at	3	30	P.M.	1019·8	+ 8·82 measures.	Clear.
Water passed at	5	55		1021·2	+16·64	Clear.
Water passed at	8	30		1030·9	+17·46	Thick from urates.
Water passed at	10	50		1023·4	0	Clear.
Water passed at	6	30	A.M.	1010·6	+ 5·93	Clear.
Water passed at	8	45		1020·9	+ 8·81	Clear.

Breakfast at $8^h\ 45^m$ A.M. on animal food only.

Water passed at	10	20		1023·1	−10·75 measures.	Clear.
Water passed at	11	0		1022·9	−29·23	Thick from phosphates.
Water passed at	12	0		1022·3	−30·75	Thick from phosphates.
Water passed at	12	50	P.M.	1023·5	−25·40	Thick from phosphates.
Water passed at	4	30		1027·6	+13·62	Thick from urates.

If these changes, represented in Plate XIX., are compared with those in Plate XVIII., it will be evident that the diminution of the acidity of the urine is very different, though the experiments were made on six consecutive days. For the three days that vegetable food was taken, the urine never was markedly alkaline; twice it was neutral to test-paper, between three and four hours after breakfast; but it never became so alkaline as when the diet was mixed, or consisted of animal food only. The breakfast, after the three days of vegetable food, consisted almost entirely of animal food, and then, for at least two hours and a half, the urine was highly alkaline. The increase in the acidity before food on the second day is very marked. It was higher than on any previous occasion. The third day, before dinner, at $5^h\ 55^m$ P.M., the acidity per 1000 grs. urine equaled 16·64 measures. At half-past eight it had increased to 17·46 measures, though in all the previous experiments the acidity diminished after dinner; but at $10^h\ 50^m$ P.M. the urine had become neutral to test-paper. Possibly this increase of acidity was owing to the honey taken at breakfast.

III. On the Influence of Medicines. (*a.*) Sulphuric acid.

For three following days dilute sulphuric acid, specific gravity 1·1077, was taken, in doses of three drachms daily. In all, nine drachms of acid were taken.

Breakfast as in experiments (1.), (2.), (3.), at $8^h\ 45^m$ A.M. Dinner, as before, at $5^h\ 45^m$ P.M. One drachm of dilute acid, in two ounces of distilled water, was taken at $7^h\ 45^m$ A.M. Another at $12^h\ 45^m$ P.M. The last at $4^h\ 50^m$ P.M.

		h	m		Spec. gr.	Acidity per 1000 grs. of urine.	
(11.)	Water passed at	7	45	A.M.	1024·8	+20·49 measures.	Thickish from urates.
	Water passed at	8	45		1022·5	+13·69	Clear.
	Water passed at	10	15		1012·6	+ 8·88	Clear.
	Water passed at	11	25		1022·5	− 8·80	Clear.
	Water passed at	12	45	P.M.	1026·1	− 3·89	Clear.
	Water passed at	3	10		1023·4	+13·68	Clear.
	Water passed at	4	50		1024·1	+21·48	Clear.

	h	m	Spec. gr.	Acidity per 1000 grs. of urine.	
Water passed at	5	45 P.M.	1026·2	+24·36 measures.	Clear.
Water passed at	10	0	1030·6	− 7·76	Clear.
Water passed at	3	15 A.M.	1018·1	+ 4·91	Clear.
Water passed at	7	0	1020·1	+14·70	Clear.

(12.) The following day breakfast as before, at $8^h\ 40^m$ A.M. Dinner as before, at $5^h\ 30^m$ P.M. A drachm of dilute sulphuric acid was taken at $8^h\ 10^m$, $12^h\ 45^m$, $4^h\ 30^m$.

Water passed at	8	40	1024·0	+14·64 measures.	Thick from urates.
Water passed at	10	0	1013·4	+ 7·88	Clear.
Water passed at	11	10	1023·3	−13·68	Clear.
Water passed at	12	0	1026·9	− 7·79	Clear.
Water passed at	12	45 P.M.	1026·1	− 3·89	Clear.
Water passed at	3	10	1023·2	+14·66	Clear.
Water passed at	5	30	1024·0	+20·50	Clear.
Water passed at	7	10	1030·4	+24·26	Thick from urates.
Water passed at	10	35	1032·6	+ 6·77	Very thick from urates.
Water passed at	3	35 A.M.	1020·0	+ 5·88	Clear.
Water passed at	6	50	1020·1	+12·74	Clear.
Water passed at	7	45	1022·6	+14·66	Clear.

(13.) The following day breakfast as before, at $8^h\ 40^m$ A.M. Dinner as before, at $5^h\ 40^m$ P.M. Dilute sulphuric acid was taken at 8^h, $1^h\ 25^m$, 5^h.

Water passed at	8	40	1023·4	+17·58 measures.	Clear.
Water passed at	9	50	1018·5	+10·80	Clear.
Water passed at	11	5	1019·9	+ 8·82	Clear.
Water passed at	12	5 P.M.	1025·5	− 4·87	Clear.
Water passed at	12	55	1026·0	+ 3·89	Clear.
Water passed at	2	50	1024·2	+14·64	Clear.
Water passed at	5	40	1023·5	+19·54	Clear.
Water passed at	7	30	1029·1	+12·63	Thick from urates.
Water passed at	10	50	1029·0	+ 2·91	Clear.
Water passed at	5	10 A.M.	1016·1	+ 8·85	Clear.
Water passed at	6	55	1016·5	+11·80	Clear.
Water passed at	8	30	1020·9	+13·71	Clear.

Plate XX. admits of a comparison with those previously given. The nine drachms of dilute sulphuric acid do not appear to heighten the acidity before food, though the diminution of the acidity after food is certainly less marked than when no acid was taken, and mixed diet was eaten. In the third part of this paper, on the Variations of the Sulphates in Health, I shall show that a similar mode of inquiry gave no positive results as to their increase in the urine after sulphuric acid was taken; but by examining all the urine passed in twenty-four hours, positive results were obtained.

A similar course was therefore adopted regarding the acidity of the urine.

These three days' variations confirm those previously given; all show the influence of digestion; the constant decrease of the acidity of the urine after food was taken, and the gradual increase of acidity as the food is absorbed.

The second day, before breakfast, it may be observed that the water made at 7 and at $8^h\ 40^m$ A.M., had very nearly the same degree of acid reaction; that is, during the last hour and forty minutes before breakfast there was no increase in the acidity of the urine. I have previously pointed out that on two occasions there was a diminution of the acidity of the urine just before breakfast.

It may, perhaps, indicate that acid is sometimes separated from the blood by the stomach previous to the food being taken.

A young physician with an irritable stomach, but otherwise in good health, made the following observations on his urine, at my request, for seven days. Breakfast was always immediately after the second testing of the water.

February 20.—$8^h\ 30^m$ A.M. slightly acid. 9 A.M. neutral. 1 P.M. alkaline.

February 21.—$8^h\ 30^m$ A.M. strongly acid. 9 A.M. slightly acid. 12 A.M. alkaline. 4 P.M. slightly acid.

February 22.—7 A.M. slightly acid. $8^h\ 30^m$ and 9 A.M. alkaline. 2 P.M. alkaline. 4 P.M. neutral. $5^h\ 30^m$ P.M. slightly acid.

February 23.—$8^h\ 30^m$ A.M. neutral. 9 A.M. alkaline. $12^h\ 30^m$ P.M. alkaline. $2^h\ 30^m$ P.M. slightly acid.

February 24.—$8^h\ 30^m$ A.M. slightly acid. 9 A.M. alkaline. $11^h\ 30^m$ A.M. alkaline.

February 25.—$8^h\ 30^m$ A.M. slightly acid. 9 A.M. neutral. 2 P.M. alkaline. 4 P.M. slightly acid.

February 26.—$8^h\ 30^m$ A.M. strongly acid. 9 A.M. slightly acid. $9^h\ 30^m$ A.M. alkaline.

Thus, just before breakfast, the urine was neutral twice, and alkaline thrice, in seven experiments.

In the previous experiments, after honey had been taken for breakfast, the acidity was seen not to diminish immediately after dinner; and the same thing happened the second day after sulphuric acid was taken; at $5^h\ 30^m$ P.M., immediately before dinner, the acidity was 20·50 measures; nearly two hours afterwards, at $7^h\ 10^m$ P.M., the acidity had increased to 24·26. At $10^h\ 30^m$ P.M. it had diminished to 6·77. The third day, with the same quantity of sulphuric acid, no increase in the acidity, two hours after food, was observed.

As no positive proof was obtained of the influence of sulphuric acid on the acidity of the urine by examining the water passed at different hours, I next endeavoured to determine whether this acid produced any effect on the total amount of acidity of the urine in twenty-four hours.

It was necessary for the purpose of comparison, that the total acidity of the urine in twenty-four hours, when sulphuric acid was not taken, should be first known. The breakfast and dinner were of meat and bread, coffee, wine and water; the same for the six days.

	A.M. h m	A.M. h m	oz.	Spec. gr.	Total carb. of soda required.
(14.) Total quantity from	7 30	to 7 30	=46¼	1022·4	=14·99 grains
					={about 8·80 measures of acid. per 1000 grs. of urine.
(15.) Total quantity from	7 30	to 7 30	=35¾	1027·1	=16·87 grains
					=about 12·65 acid. per 1000 urine.
(16.) Total quantity from	7 30	to 7 30	=44	1023·8	=14·31 grains
					=about 8·78 acid. per 1000 urine.

During each of the three following days, three drachms of dilute sulphuric acid, specific gravity 1·1077, were taken, in three and a half ounces of distilled water; the greater part from 9 to 12 A.M.

	A.M. h m	A.M. h m	oz.	Spec. gr.	Total carb. of soda required.
(17.) Total quantity from	7 30	to 7 30	=40	1026·2	=17·59 grains
					={about 11·88 measures of acid. per 1000 grs. of urine.
(18.) Total quantity from	7 30	to 7 30	=54	1020·3	=17·64 grains
					=about 8·82 acid. per 1000 urine.
(19.) Thick from urates . . .			=40	1028·6	=25·92 grains
					=about 17·50 acid. per 1000 urine.

From the comparison of the total amount of carbonate of soda required to neutralize the acidity of the urine, there is no doubt that sulphuric acid does slightly increase the acidity of the urine. The following day no examination was made.

	A.M. h m	A.M. h m	oz.	Spec. gr.	Total carb. of soda required.
Total quantity from	7 30	to 7 30 the next day	=45	1026·7	=4·82 grains
					={about 3·89 measures of acid. per 1000 grs. of urine.

The conclusions from these experiments are,—

I. As regards the variations of the acidity of the urine for three days on mixed diet. The acidity soon after food was found to decrease, and to attain its lowest limit from three to five hours after breakfast and dinner; sooner, however, after breakfast than after dinner. The acidity then gradually increased, and attained its highest limit just before food. Once previous to breakfast, the urine was found more acid an hour before breakfast than it was immediately before food.

If no food was taken the acidity of the urine did not decrease, but remained nearly the same for twelve hours. It fell immediately after food was taken.

II. As to the influence of animal and vegetable food.

When animal food only was taken, the diminution of the acidity after food was more marked and more lasting, than when a mixed diet was taken; and the acidity before food rose rather higher with a mixed diet than it did with animal food.

When vegetable food only was taken the contrast with animal food was very marked. The urine did not decrease in acidity to the same degree; though it became neutral, it did not become highly alkaline. The increase in the acidity of the urine was by no means so marked as the decrease of the alkalescence. The acidity of the urine was rather higher with the vegetable food than it was with animal food.

III. As to the effect of dilute sulphuric acid.

Dilute sulphuric acid, taken in large doses, did not produce any very decided results. Nine drachms of dilute acid in three days slightly diminished the decrease in the acidity of the urine after food. The acidity before food was very slightly, if at all, increased thereby.

When the acidity of the whole quantity of water passed in twenty-four hours, for three days when no sulphuric acid was taken, is compared with the acidity when nine drachms of dilute sulphuric acid were taken, the increase is sufficiently distinct to prove that the acid does pass off in the urine.

The result of these experiments is, that the acidity of the urine is always changing, and that the changes depend on the state of the stomach.

When much acid is in the stomach, the acidity is then diminished. As the acid returns from the stomach, the acidity of the urine increases, and usually reaches its highest limit before food is again taken.

Animal food causes a greater oscillation in the acidity of the urine than vegetable food does; and when no food is taken the oscillation is very small.

The diurnal variations in the acidity of the urine make it highly probable that corresponding variations occur in the alkalescence of the blood; such diurnal variations being produced by the quantity of acid poured into the stomach for the purpose of dissolving the food.

When the food is irritating, or the stomach in an irritable state, much acid is poured out, and the effects on the blood and urine are more marked than they are when less acid is secreted.

Dr. Prout's capital experiment of hydrochloric acid in the stomach during digestion, gives the key to these diurnal variations of the acidity of the urine, and may lead to the discovery of the diurnal variations of the alkalescence of the blood.

Part II.—*On the Simultaneous Variations of the amount of Uric Acid and the Acidity of the Urine in a Healthy State.*

The variations which occur in the acidity of the urine are of themselves of very great interest, whether in relation to health or to disease; whilst the determination of the amount of uric acid and acidity at the same time directly solves the question, whether the acidity of the urine depends on the uric acid; and thus alone can clear views of the causes of the precipitation of the urate of ammonia in the urine be obtained. Moreover, it is necessary to trace fully the variations of the uric acid in health before deductions can safely be made regarding the variations of the amount of uric acid in different diseases.

The following course was taken. A healthy man who took food twice daily, and moderate exercise for three hours, was the subject of the experiments. A bottle containing 1000 grains of water was filled with urine, at a temperature of 60°. It was weighed, and the fluid was heated to 120°, when a test alkaline solution was dropped from a graduated tube, and well-stirred, until the urine became just neutral to very delicate test-paper.

The test solution was prepared by taking dry and pure carbonate of soda, and dissolving it in so much water that every measure of a graduated tube contained $\frac{1}{12}$th of a grain of carbonate of soda in solution.

To determine the amount of uric acid, upwards of 2000 grains of urine were mixed with strong hydrochloric acid, in the proportion of a drachm to the ounce, and left to stand for at least twenty-four hours. The fluid was poured off, and the residue thrown on a weighed filter, slightly washed, and dried *in vacuo* over sulphuric acid.

(1.) Breakfast on bread, coffee, and two eggs, at 9 A.M. Dinner at $7\frac{1}{2}$ P.M. Fish meat, and vegetables, with water.

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
Water passed at P.M. 2 clear.	1023·1	9·77	0·39
Water passed at 7 clear.	1026·3	27·28	0·048
Water passed at 11 cloudy.	1030·0	26·21	0·584
(2.) The following day, breakfast as yesterday. Dinner at $6\frac{1}{2}$ P.M.			
Water passed at 2 slightest cloud.	1025·4	4·88	0·731
Water passed at $6\frac{1}{2}$ clear.	1026·7	23·37	0·14
Water passed at 11 clear.	1025·1	7·80	0·61
(3.) Following day, breakfast as before. Dinner at $6\frac{1}{4}$ P.M.			
Water passed at 1 clear.	1025·5	9·75	0·53
Water passed at $6\frac{1}{4}$ clear.	1023·1	22·48	0·17
Water passed at 11 clear.	1031·1	11·64	0·92
(4.) As yesterday. Dinner at $\frac{1}{4}$ to 6 P.M.			
Water passed at $1\frac{1}{4}$ very thick.	1027·8	23·35	0·53
Water passed at $5\frac{3}{4}$ clear.	1027·7	27·24	0·12
Water passed at $10\frac{1}{2}$ clear.	1021·0	13·71	0·39
(5.) As yesterday. Dinner at 7 P.M.			
Water passed at $2\frac{1}{2}$ clear.	1023·1	17·59	0·44
Water passed at 7 clear.	1024·9	30·24	0·146
Water passed at 11 clear.	1026·5	9·74	0·634
Average mean of five days.			
Between 1 and 2 P.M.	1025·0	13·07	0·52
Between 6 and 7 P.M.	1025·7	26·12	0·12
Between 10 and 11 P.M.	1026·7	13·81	0·62

From these experiments it appears that the uric acid is increased three, four, or five times in quantity by food; whilst the acidity is lessened to one-half what it was before food. The quantity of uric acid varies before food from 0·048 gr. per 1000 grs. of urine, specific gravity 1026·3, to 0·17 gr. per 1000 grs. of urine, specific gravity 1023·1. After food the quantity of uric acid varies from 0·39 gr. per 1000 grs. of urine, specific gravity 1021·0, to 0·92 gr. per 1000 grs. of urine, specific gravity 1031·1. The acidity before food varies from 23·37 grs. per 1000 grs. of urine, specific gravity 1026·7, to 30·24 per 1000 urine, specific gravity 1024·9. After food the acidity varies from 7·80 per 1000 urine, specific gravity 1025·1, to 26·21 per 1000 urine, specific gravity 1030·0.

The uric acid was lowest when 0·048 gr. per 1000 grs. of urine, specific gravity 1026·3, was present, then the acidity was 27·28 measures. The uric acid was highest when there was 0·92 gr. per 1000 grs. of urine, specific gravity 1031·1; the acidity then was 11·64 measures only.

(6.) A child twenty-three months old, fed at 1 P.M. on bread with some meat and milk, gave—

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
Water passed at 1 P.M.	1013·6	8·88	0·27
Water passed at 5 P.M.	1022·0	14·67	0·65

Both specimens deposited uric acid crystals on standing; the first in twenty-four hours, the last in six hours.

II. I next endeavoured to ascertain what was the influence of different kinds of food on the variations of the uric acid and acidity.

For three successive days vegetable food alone was taken, with water and coffee. Breakfast at 9¼ A.M. Dinner at 6¼ P.M.

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
(7.) Water passed at 1¼ P.M. A few uric acid crystals formed on long standing	1022·9	17·60	0·19
Water passed at 6¼ P.M. clear .	1025·4	21·45	0·17
Water passed at 10¼ P.M. clear .	1014·8	12·81	0·19
(8.) Breakfast and dinner as yesterday. Water at 10½ A.M. thrown away, clear.			
Water passed at 2½ P.M. clear .	1021·65	8·89	0·565
Water passed at 6¼ P.M. clear .	1024·0	26·36	0·049
Water passed at 10½ P.M. clear .	1026·2	3·29	0·636
Water passed at 6½ A.M. clear .	1024·2	19·52	0·665
(9.) Breakfast and dinner the same as yesterday. Water at 9 thrown away.			
Water passed at 10½ A.M. thick on standing from urates . . .	1025·6	12·67	1·01

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
Water passed at 2½ P.M. cloudy from phosphates	1024·5	alkaline	0·61
Water passed at 6½ P.M. clear .	1025·9	26·31	0·34
Water passed at 10½ P.M. clear .	1014·8	alkaline	0·14
Water passed at 6½ A.M. clear .	1014 8	7·88	0·049

When vegetable food only is taken the same variations are seen as when mixed diet is eaten. The acidity is most before food. The highest acidity was 26·36 measures; then the uric acid =0·049 gr. per 1000 grs. of urine, specific gravity 1024·0. The uric acid was most after food; the highest amount being 1·01 gr. per 1000 grs. of urine, specific gravity 1025·6. The acidity then was only 12·67 measures per 1000 grs. of urine. The variations of the acidity in (9.) are very remarkable.

For three days in succession animal food only was taken, meat, eggs, cheese, coffee and water. Breakfast at 9 A.M. Dinner at a quarter to 6 P.M.

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
(10.) Water passed at 9 A.M. clear, uric acid crystals in four hours .	1023·3	30·41	0·69
Water passed at 11 A.M. clear .	1015·2	alkaline	0·24
Water passed at 1 P.M. thick from phosphates	1022·2	alkaline	0·68
Water passed at ¼ to 6 P.M. clear	1023·9	20·50	0·34
Water passed at 10¼ P.M. clear	1024·1	11·71	0·63
(11.) Breakfast at 9 A.M. Dinner at half-past 6 P.M.		Food as before.	
Water passed at 2½ P.M. clear	1022·7	7·82	0·44
Water passed at 6½ P.M. clear	1024·8	21·46	0·049
Water passed at 11½ clear	1029·9	16·50	0·77
(12.) Breakfast at 9 A.M. Dinner at half-past 6 P.M.		Animal food only.	Water at 9 A.M. thick, and was thrown away.
Water passed at 2½ P.M. thick	1024·7	16·59	0·756
Water passed at 6½ P.M. clear	1027·1	24·34	0·073
Water passed at ¼ to 11 P.M. thick	1027·8	18·48	1·022
Water passed at 4½ A.M. clear	1021·4	16·64	0·318

In these experiments also the uric acid is increased after food, and the acidity is diminished. The highest amount of uric acid was 1·022 gr. per 1000 grs. of urine, specific gravity 1027·8. The acidity at the same time was 18·48 measures. Previous to food the same day the uric acid =0·073 gr. per 1000 grs. of urine, specific gravity 1027·1; then the acidity =24·34 measures.

Comparing the three days on animal food with the three days on vegetable food, we have the highest amount of uric acid on the third day; in the one case =1·022 gr.,

specific gravity 1027·8, and in the other 1·01 gr. per 1000 grs. of urine, specific gravity 1025·6, after dinner in the one case and after breakfast in the other. The lowest amount in both was 0·049 gr. per 1000 urine, specific gravity 1024·8; and 0·049 gr., specific gravity 1024·0, in both instances before dinner. So that neither as regards the diminution nor the increase of the amount of uric acid can any positive result be obtained from these experiments on the influence of animal and vegetable food.

The variations in the acidity are not very different on animal or on vegetable food; the acidity rises higher when vegetable food is taken than when animal food only was taken.

I next endeavoured, if possible, to determine the effect of exercise. No food was taken from dinner on the previous day to dinner this day at a quarter to six; both meals consisted of mixed diet of bread, meat and potatoes. The exercise was moderate between three and six.

No water was passed from 11 the previous night to 6 A.M.

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
(13.) Water passed at 6 A.M. clear .	1026·7	13·63	0·63
Water passed at 11 A.M. clear .	1024·3	19·52	0·63
Water passed at ¼ to 6 P.M. . .	1027·9	12·65	0·73
Water passed at 11 P.M. clear .	1021·0	alkaline	0·49
Water passed at 6 A.M. clear .	1022·3	22·49	0·58

(14.) Nothing was taken from dinner on the previous day until 5½ P.M. this day. Strong exercise was taken from 2½ to 5½ P.M. Pulse always above 100. At nine urine clear and thrown away.

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
Water passed at 1 P.M, few uric acid crystals	1022·5	19·56	0·344
Water passed at 5½ P.M. clear	1025·2	25·36	0·268
Water passed at 10½ P.M. very thick, some uric acid crystals.	1030·0	19·41	1·286
Water passed at 1½ A.M. very thick, some uric acid crystals	1027·1	17·52	0·924
Water passed at 7 A.M. very thick, some crystals of uric acid	1025·5	33·14	0·878

(15.) Nothing was taken from dinner on the previous day until ten minutes after five this day. Moderate exercise was taken from 2 to 5 P.M.

	Spec. gr.	Acidity per 1000 grs. of urine. measures.	Uric acid per 1000 grs. of urine. grain.
Water passed at 6 10 A.M. clear . .	1025·7	15·59	0·098
Water passed at 11 20 A.M. thick .	1024·8	13·96	0·61
Water passed at 5 10 P.M. thick . .	1028·3	14·90	0·52
Water passed at 11 P.M. clear . .	1031·1	2·85	0·87
Water passed at 5 40 A.M. clear . .	1026·9	10·71	0·12

Hence no conclusion can be drawn regarding the effect of exercise on the excretion of uric acid. The influence of food lasts so long in increasing the amount of urates that no results regarding exercise could be obtained; experiment (14) is no positive proof of the increase or diminution of the uric acid by exercise.

The three following days the total amount of uric acid excreted in twenty-four hours was determined. The breakfast and dinner were of meat and bread, coffee, wine and water: the same each day.

	Uric acid. gr.	Spec. gr.	Quantity of urine.	Uric acid per 1000 grs. of urine.
(16.) Total quantity from $7^h\ 30^m$ A.M. to $7^h\ 30^m$ A.M.	=5·9	1022·4	=46$\frac{1}{4}\frac{z}{3}$	0·29 gr.
(17.) The following day. Total quantity . .	=7·7	1027·1	=35$\frac{3}{4}\frac{z}{3}$	0·48
(18.) The following day. Total quantity . .	=7·0	1023·8	=44$\frac{z}{3}$	0·36

In the course of the following three days nine drachms of dilute sulphuric acid were taken. The food was the same as before.

	Uric acid. gr.	Spec. gr.	Quantity of urine.	Uric acid per 1000 grs. of urine.
(19.) Total quantity from $7^h\ 30^m$ A.M. to 7^h A.M. .	.=7·3	1026·2	=40$\frac{z}{3}$	0·41 gr.
(20.) The following day, total quantity . . .	.=6·5	1020·3	=54$\frac{z}{3}$	0·27
(21.) Thick from urates, the following day, quantity	=9·9	1028·6	=40$\frac{z}{3}$	0·56

The conclusions from these experiments are,—

I. As regards the variations of the acidity and uric acid when mixed diet was taken.

	Per 1000 grs. of urine.	Spec. gr.
The uric acid varies before food from . . .	0·048 gr.	1026·3
The uric acid varies before food to	0·17 gr.	1023·1
It varies after food from	0·39 gr.	1021·0
It varies after food to	0·92 gr.	1031·1
The acidity varies before food from	23·37 measures	1026·7
The acidity varies before food to	30·24 measures	1024·9
It varies after food from	7·80 measures	1025·1
It varies after food to	26·21 measures	1030·0

II. As to the influence of vegetable and animal food and exercise.

When vegetable food only was taken the uric acid was highest after food,

	Per 1000 grs. of urine.	Spec. gr.
Being at most	1·01 gr.	1025·6
Then the acidity was	12·67 measures	
The uric acid was least before food, being at least	0·049 gr.	1024·0
Then the acidity was	26·36 measures	

When animal food only was taken the uric acid was highest after food,

Being at most	1·022 gr.	1027·8
Then the acidity was	18·48 measures	
The lowest uric acid was before food, being at least	0·049 gr.	1024·8
Then the acidity was	21·46 measures.	

There is no great difference between animal and vegetable food; and no proof was obtained of the influence of exercise on the excretion of uric acid.

From the experiments on the total amount of uric acid excreted in twenty-four hours, it appears as though the deficiency one day was followed by an excess the following day.

The result of these experiments is, that there is no relation between the acidity of the urine and the amount of uric acid in it. The urine that was most acid contained least uric acid. That which contained most uric acid was not highly acid.

All food causes an increase in the amount of uric acid in the urine, and there is no decided difference between vegetable and animal food, either as to the increase or diminution of the amount of uric acid in the urine.

These experiments also show the variations of the acidity of the urine which the food produces. They were made four months previous to the experiments in the first part of this paper, which were made in October. Those here given were made in June.

On the Deposit of Urates in the Urine.

That the amount of urates in the urine is not the only cause of their deposit, the following experiments are sufficient to prove:—

	h	m		Spec. gr.	Acidity and uric acid per 1000 grs. of urine.	grain.	
Water passed at	5	5	P.M.	1024·9	18·53 measures	0·22	No deposit.
Water passed at	7	35		1029·2	15·54	0·29	Thickish from urates.
Water passed at	10	5		1027·2	alkaline	0·33	No deposit.
Another day at	5	50	P.M.	1024·4	21·47	0·07	No deposit.
	7	55		1029·6	15·57	0·31	Thickish from urates.
	10	45		1029·8	alkaline	0·90	No deposit.
Another day at	10		P.M.	1030·6	alkaline	0·76	No deposit.
The same is well seen in (15.).							
at	5	10	P.M.	1028·3	14·90	0·52	Thick from urates.
	11			1031·1	2·85	0·87	Clear.

The influence of temperature is always shown in the precipitation of urates taking place on the cooling of the urine. The low temperature of the night frequently will cause a deposit which would not form during the day.

The influence of the acidity of the urine on the deposit can always be shown by adding any acid to the urine passed soon after food. Two portions being taken, and the one being made more acid than the other, will show a difference in the time or degree of deposit.

The influence of water in preventing a deposit is shown, by adding distilled water to urine which would give a precipitate. Evaporation under the air-pump takes away

water, increases the proportion of urate of ammonia to the water, at the same time it increases the acid reaction of the urine. By carrying the evaporation far enough, deposit of urate of ammonia always occurs.

The influence of strong light is seen in its occasionally causing a deposit only on the side of the glass nearest to the light. Brisk agitation also sometimes will hasten or cause a deposit of urate of ammonia.

From the above experiments and observations, it follows that the deposit of urate of ammonia does not generally depend only on the proportion of the water to the urate of ammonia being relatively or positively diminished. Nor does it depend solely on the degree of acidity of the urine; but it results from the simultaneous action of both causes, aided always by a low temperature.

Alkaline urine will hold in solution a great excess of urate of ammonia, and very feebly acid urine will dissolve much more urate of ammonia than very highly acid urine. But highly acid urine will give no precipitate of urate of ammonia if only a very small quantity of that substance is present in it.

The deposit of urate of ammonia is therefore the result of the united action of three causes:—

1. Decrease of temperature.
2. Increased proportion of urate of ammonia to the water, positively or relatively.
3. Increased acidity of the urine.

Sometimes one cause, sometimes the other, is the most efficient; but they are all usually concerned in causing the deposit of urate of ammonia.

Part III.—*Variations of the Sulphates in the Urine in the healthy state, and on the influence of Sulphuric Acid, Sulphur and the Sulphates, on the amount of the Sulphates in the Urine.*

Before tracing the variations of the sulphates in disease, it is necessary to determine their limits in the healthy state; and it is also desirable to know as far as possible what the effect of medicinal substances on their amount may be. Thus the influence of sulphuric acid, of the sulphates, and of sulphur on the amount of sulphuric acid excreted, must be determined before the results of diseased action can be estimated. By this means alone can it be shown what is the effect of ordinary causes or remedies, and what is the effect of disease.

A healthy man taking food twice daily, with moderate exercise for three hours, was the subject of the following experiments. The specific gravity of the urine was first taken. To a weighed quantity, usually about 500 grains, chloride of barium in excess was added, and then a few drops of nitric acid. Heat was then applied until the liquid boiled briskly, when the sulphate of baryta was filtered, well-washed, and ignited in a platinum crucible, after which it was weighed.

By this method very accurate results could be obtained.

(1.) Breakfast on bread and cocoa at 8½ A.M. Dinner on meat, potatoes, bread and water at 6½ P.M.

	Spec. gr.	Sulphate of baryta per 1000 grs. of urine. grains.
Water passed at 3 P.M. filtered	1028·2	9·16
Water passed at 6½ clear	1027·0	8·41
Water passed at 10½ filtered	1033·9	15·23

(2.) Food as before. Between 3 and 7 P.M. strong exercise was taken. Dinner at 7 P.M.

Water passed at 7 P.M. clear	1025·3	7·07
Water passed at 11 filtered	1030·8	11·53
Water passed at 1 A.M. clear	1025·1	6·47

(3.) Breakfast at 9 A.M. as before. Dinner at 6½ P.M.

Water passed at 3½ P.M. filtered	1026·8	7·96
Water passed at 6½ clear	1027·0	7·36
Water passed at 10½	1031·0	10·63

(4.) Breakfast at 9 A.M. as before. Water passed at 10 A.M. thrown away. Dinner 6¼ P.M.

Water passed at 12½ P.M. filtered	1025·6	7·52
Water passed at 3½	1025·9	7·95
Water passed at 6¼	1026·0	8.25
Water passed at 10½ clear	1029·3	9·45

(5.) Breakfast at 9 A.M. as before. Dinner at 5½ P.M.

Water passed at 1 P.M. clear	1024·0	6·48
Water passed at 3¼	1023·6	6·03
Water passed at 5½	1027·6	8·56
Water passed at 9½ filtered	1030·8	12·43
Average mean of five days after dinner, with perfect rest	1031·1	11·85
Average mean of five days just before dinner, after exercise	1026·5	7·93
Average of four days, longer before dinner	1026·1	7·77

From these experiments it appears that the sulphuric acid is much increased in the water passed after food, the quantity varying—

From 15·23 grs. of sulphate of baryta per 1000 grs. of urine, specific gravity 1033·9
To 9·49 grs. of sulphate of baryta per 1000 grs. of urine, specific gravity 1029·3

The mean of all the experiments after food being 11·85 per 1000 urine, specific gravity 1031·1.

The quantity of sulphuric acid is much less in the water secreted a long time after food, varying—

From 8·56 grs. of sulphate of baryta per 1000 grs. of urine, specific gravity 1027·6
To 7·07 grs. of sulphate of baryta per 1000 grs. of urine, specific gravity 1025·3

The mean of all the experiments before food being 7·93 grs. per 1000 grs. of urine, specific gravity 1026·5.

(6.) A child two years old, fed on bread with some meat and milk, gave in the water passed during the night, acid, specific gravity =1014·6, sulphate of baryta 4·66 grs. per 1000 grs. of urine.

(7.) On the same food another night, specific gravity =1013·5, sulphate of baryta 3·88 grs. per 1000 grs. of urine.

II. I next endeavoured to ascertain by what causes the variations were produced. And first (*a.*) with regard to food of different kinds. For three consecutive days bread alone, with a little rice and water and tea, was taken at the same hours as food had been taken in the previous experiments.

		Spec. gr.	Sulphate of baryta.
(8.) Water passed at 6 P.M.	clear	1019·46	5·31 grs. per 1000 grs. of urine.
Water passed at 11	filtered	1025·30	10·57
(9.) Breakfast and dinner as on the previous day. Distilled water only was taken.			
Water passed at 3 P.M.	filtered	1025·88	8·03 grs. per 1000 grs. of urine.
Water passed at 6 . .		1026·00	7·31
Water passed at 11 . .		1030·40	13·21
(10.) Breakfast and dinner as on the previous day. Spring water drunk.			
Water passed at 3 P.M. . .		1027·56	9·53 grs. per 1000 grs. of urine.
Water passed at 6 . .		1028·58	9·46 per 1000 urine.
Water passed at 11 . . .		1031·86	13·68

(11.) Animal food only was taken for three days with tea and water. Breakfast at 9 A.M.: animal food and tea. Dinner at 6 P.M.: animal food and water. 1 P.M. water was thrown away.

Water passed at 6 P.M.	clear	1023·02	6·86 grs. per 1000 grs. of urine.
Water passed at 11 . . .		1021·10	7·69
(12.) Breakfast and dinner as on the previous day. Distilled water only taken.			
Water passed at 3 P.M. . .		1021·30	6·30 grs. per 1000 grs. of urine.
Water passed at 6 . . .		1025·52	9·12
Water passed at 11 . . .		1023·60	10·19
(13.) Breakfast and dinner as on the previous day. Common water taken.			
Water passed at 3 P.M.	filtered	1023·92	8·36 grs. per 1000 grs. of urine.
Water passed at 6	clear	1025·44	9·30
Water passed at 11	filtered	1026·24	11·14

From the comparison of these numbers with the average previously given, no deduction can be drawn as to the peculiar influence of animal or vegetable food on the amount of the sulphates in the urine. After either animal or vegetable food the sulphates are increased.

II. (*b.*) I then tried to determine the effect of exercise.

(14.) Nothing whatever was taken from dinner the preceding day, which consisted of meat only, until dinner this day, which consisted of bread, tea, and an egg. The

water made at a quarter to 2 P.M. was thrown away. From four to a quarter past 6 moderate and sometimes strong exercise was taken.

	Spec. gr.	Sulphate of baryta.
Water passed at 4 P.M. filtered .	1029·52	8·76 grs. per 1000 grs. of urine.
Water passed at $6\frac{1}{4}$ . . .	1031·18	11·26 11·23
Water passed at $10\frac{1}{4}$ . . .	1029·04	12·34

(15.) Nothing whatever was taken from dinner the preceding day, which consisted of bread and meat, until dinner this day. Water made at 1 P.M. thrown away. From 3 to 6, at times, gentle exercise was taken.

	Spec. gr.	Sulphate of baryta.
Water passed at 3 P.M. filtered .	1024·78	5·48 grs. per 1000 grs. of urine.
Water passed at 6	1026·88	7·03
Water passed at 11	1027·50	9·34

(16.) Nothing was taken from dinner the preceding day to dinner this day. The water passed at 1 P.M. was thrown away. From 3 to 6 strong exercise was taken.

	Spec. gr.	Sulphate of baryta.
Water passed at 3 P.M. filtered .	1021·20	3·27 grs. per 1000 grs. of urine.
Water passed at 6	1019·10	3·55 3·47
Water passed at $10\frac{1}{2}$ clear . .	1027·00	8·00

From these numbers it appears that food has more influence on the sulphates than exercise has. (14.) shows that exercise has a decided effect in increasing the sulphates. The increase is less marked in (15.); the same is seen in (16.) to a much less degree in consequence of the diminution of the specific gravity.

III. The influence of different medicinal substances admits of a clearer demonstration.

(*a*.) (17.) Breakfast as before at 9 A.M. Dinner at $6\frac{1}{2}$ P.M. At 1 P.M. thirteen drops of sulphuric acid, specific gravity = 1786·4, equivalent to above $1\frac{1}{4}3$ of dilute sulphuric acid, were taken in water.

	Spec. gr.	Sulphate of baryta.
Water passed at 1 P.M. clear . .	1027·6	7·51 grs. per 1000 grs. of urine.
Water passed at 3 . . .	1028·7	9·75
Water passed at $6\frac{1}{2}$ . . .	1027·9	10·36
Water passed at 10 . . .	1031·5	12·15

(18.) Breakfast as before. Dinner at 6 P.M. At 1 P.M. rather less sulphuric acid was taken.

	Spec. gr.	Sulphate of baryta.
Water passed at $12\frac{1}{2}$ P.M. . . .	1022·5	4·07 grs. per 1000 grs. of urine.
Water passed at 3	1022·2	5·28
Water passed at 6	1021·9	6·19
Water passed at $10\frac{1}{2}$	1028·1	10·66

(19.) Breakfast as before. Dinner at 6 P.M. At 1 P.M. thirteen drops of sulphuric acid as before.

	Spec. gr.	Sulphate of baryta.
Water passed at 1 P.M. . . .	1018·8	3·48 grs. per 1000 grs. of urine.
Water passed at $\frac{1}{4}$ to 3 . . .	1012·6	2·13
Water passed at 6	1017·7	4·09
Water passed at 10	1026·2	11·43

(20.) Breakfast as before. Dinner at 6 P.M. At 1 P.M. twenty drops of sulphuric acid taken as before.

Water passed at 1 P.M. . . .	1022·8	4·83 grs. per 1000 grs. of urine.
Water passed at 3	1019·9	4·99
Water passed at 6	1022·2	6·79
Water passed at $10\frac{1}{2}$	1021·3	9·52

(21.) Breakfast as before. Dinner as before. No sulphuric acid taken.

Water passed at 3 P.M. . . .	1025·0	7·08 grs. per 1000 grs. of urine.
Water passed at 6	1023·9	5·88
Water passed at $10\frac{1}{2}$	1029·4	10·79

From experiment (17.) it seemed that the sulphates were slightly increased by the sulphuric acid which was taken. The other experiments hardly confirm this deduction, and on this account I tried whether a course of sulphuric acid would give more marked results.

(22.) After four days in which dilute sulphuric acid, specific gravity 1115·3, was taken; three drachms the first day and two drachms the three following days. Breakfast and dinner the day after the course of sulphuric acid were the same as in the previous experiments.

		Spec. gr.	Sulphate of baryta.
Water passed at 1 P.M.	clear . .	1027·4	7·51 grs. per 1000 grs. of urine.
Water passed at 3	filtered .	1025·4	8·73
Water passed at 6	clear . .	1026·5	8·72
Water passed at $10\frac{1}{4}$	filtered .	1030·2	11·99

(23.) No sulphuric acid was taken on the day of experiment (22.). For the next three days three drachms of dilute sulphuric acid were taken the first day, two drachms the second, and three drachms the third day.

The following day (seventeen drachms of dilute sulphuric acid having been taken in the eight previous days) the breakfast and dinner were as before.

		Spec. gr.	Sulphate of baryta.
Water passed at 1 P.M.	filtered .	1026·0	7·37 grs. per 1000 grs. of urine.
Water passed at 3	. . . .	1025·9	7·22
Water passed at $6\frac{1}{2}$	clear . .	1023·3	5·43
Water passed at 10	filtered .	1028·1	10·66

From these experiments it does not appear at all certain that dilute sulphuric acid does pass off in the urine. The question being still undecided, the amount of sulphates in the whole quantity of water passed in twenty-four hours, for three successive days, when no sulphuric acid had been taken, was compared with the amount of sulphates in the whole quantity of water passed in twenty-four hours, for the three succeeding days, when sulphuric acid had been taken. The breakfast and dinner were the same for the six days.

	Spec. gr.	Sulphate of baryta.
(24.) Total quantity of water passed in twenty-four hours, from 7 A.M. to 7 A.M. $=37\frac{1}{2}$ ounces, filtered	1024·2	7·75 grs. per 1000 grs. of urine. 7·66
(25.) The following day $=42$ ounces, clear	1023·4	9·18 9·20
(26.) The following day $=34$ ounces, filtered	1026·1	7·83

During each of the three following days half an ounce of dilute sulphuric acid, specific gravity $=1108{\cdot}4$, was taken in distilled water, the greater part from 9 to 12 A.M.

	Spec. gr.	Sulphate of baryta.
(27.) Total quantity 46 ounces, filtered	1024·2	9·56 grs. per 1000 grs. of urine. 9·64
(28.) The following day $42\frac{1}{2}$ ounces, clear	1024·0	11·66 11·64
(29.) The following day 43 ounces, clear	1025·4	13·10 12·81

By comparing these experiments, it is certain that dilute sulphuric acid, taken in very large quantity, does cause an increase in the amount of sulphates passing off in the urine.

III. (*b.*) (30.) Breakfast at 9 A.M. Dinner at 6 P.M.: the water made at 11 A.M. was thrown away, and $61\frac{1}{2}$ grains of dry sulphur in fine powder were taken.

	Spec. gr.	Sulphate of baryta.
Water passed at 1 P.M. filtered .	1020·2	5·44 grs. per 1000 grs. of urine.
Water passed at 6	1023·1	7·99
Water passed at 11	1027·6	13·37
(31.) Experiment repeated.		
Water passed at 1 P.M. clear. .	1012·2	2·89
Water passed at 6	1020·7	6·20
Water passed at 11 filtered .	1026·2	11·76
(32.) Experiment repeated.		
Water passed at 1 P.M. clear. .	1014·6	4·19
Water passed at 6	1022·5	10·26
Water passed at 11 filtered . .	1025·4	15·05

(33.) Experiment repeated.

	Spec. gr.	Sulphate of baryta.
Water passed at 1 P.M. clear	1018·9	6·81 grs. per 1000 grs. of urine.
Water passed at 3 .	1018·0	6·52
Water passed at 6 .	1025·6	11·89
Water passed at 11 filtered	1027·9	14·74

(34.) Experiment repeated.

Water passed at 1 P.M. filtered	1023·0	7·99
Water passed at 3 clear . .	lost	
Water passed at 6 clear .	1020·7	7·11
Water passed at 11 filtered .	1028·8	15·15

$61\frac{1}{2}$ grains of dry sulphur taken each day.

Average of five days after dinner and rest	1027·1	14·01 grs. per 1000 grs. of urine.
Immediately before dinner after exercise	1022·5	8·69

Comparing this average of experiments 30, 31, 32, 33, 34, with the average of experiments 1, 2, 3, 4, 5, it is seen that the sulphates are positively increased in the urine when sulphur is taken into the stomach.

III. (*c.*) (35.) Breakfast 9 A.M. Dinner at $6\frac{1}{2}$ P.M.: at 1 P.M. $123\frac{1}{2}$ grains of dry sulphate of potash were taken in $1\frac{1}{2}$ ounce of distilled water. It did not act on the bowels.

	Spec. gr.	Sulphate of baryta.
Water passed at 1 P.M. clear	1017·7	3·03 grs. per 1000 grs. of urine.
Water passed at 3 . . .	1016·7	3·00
Water passed at $6\frac{1}{2}$ . . .	1020·8	6·65
Water passed at $10\frac{1}{2}$ . . .	1026·0	12·18

(36.) The same quantity of sulphate of potash taken at 11 A.M.

Water passed at 1 P.M. clear	1020·2	3·17
Water passed at $3\frac{1}{2}$ . .	1024·0	8·74
Water passed at $6\frac{1}{2}$ . .	1024·2	12·51
Water passed at $10\frac{1}{2}$ . .	1032·4	20·49

(37.) Experiment repeated.

Water passed at 1 P.M. clear	1021·6	3·17
Water passed at 3 . .	1021·4	4·98
Water passed at 6 . .	1024·0	9·04
Water passed at $10\frac{1}{2}$ filtered	1030·8	15·72

Hence 123 grains of sulphate of potash began to increase the amount of sulphates in the urine from four to six hours after they were taken; and the effect was strongly marked from seven to twelve hours afterwards.

In my next paper, on the sulphates in the urine in disease, many instances will be

given of an increase in the amount of sulphates in consequence of sulphate of magnesia having been taken in doses of about 2 drachms. The highest instances were—

	Spec. gr.	Sulphate of baryta.
In one case urine . .	1028·0	contained 15·89 grs. per 1000 grs. of urine.
In another case urine .	1024·3	contained 22·55 grs.

The conclusions from these experiments are,—

I. That the sulphate of baryta varies soon after food from 15·23 grs. per 1000 grs. of urine, specific gravity 1033·9, to 9·45 grs. per 1000 grs. of urine, specific gravity 1029·3. It varies long after food from 8·56 grs. per 1000 grs. of urine, specific gravity 1027·6, to 7·07 grs. per 1000 grs. of urine, specific gravity 1025·3.

II. As to the causes of variation—(*a*) as regards food; (*b*) as regards exercise.

(*a*) Food, whether animal or vegetable, causes an increase in the quantity of sulphate of baryta precipitated, but the difference between animal and vegetable food is not well-marked.

(*b*) Exercise appears slightly to increase the amount of sulphates in the urine, but the increase is not so marked as it is after food.

III. As to the effect of medicines on the sulphates,—(*a*) sulphuric acid; (*b*) sulphur; (*c*) sulphates.

(*a*) Thirteen drops of strong sulphuric acid in one of three experiments increased the sulphates in the urine. Twenty drops of the same acid gave no positive proof.

Seventeen drachms of dilute sulphuric acid, taken in eight days, gave no positive proof of an increase of sulphates in the urine on the ninth day.

But when the whole quantity of urine passed in twenty-four hours for three successive days, when no sulphuric acid had been taken, was compared with the whole quantity passed in twenty-four hours, when half an ounce of dilute sulphuric acid was taken, then for three successive days that the experiment was made, the increase of sulphates was most marked. And from this it is certain, that when a large quantity of dilute sulphuric acid is taken the sulphates are increased in the urine. When small quantities of sulphuric acid are taken the effect on the sulphates in the urine is not detectable.

(*b*) 61½ grains of dry sulphur, taken for five days, gave an average amount of sulphates in the urine, both before and after food, higher than when no sulphur was taken. But with this dose the increase, though decided, was not considerable.

(*c*) 123½ grains of sulphate of potash produced a marked increase from two to four hours afterwards. In seven hours the increase was more marked. Sulphate of magnesia had a similar effect. The increase in the sulphates in the urine was much more evident than when sulphur or sulphuric acid were taken.

The result of these experiments is—

1st. That the sulphates in the urine are much increased by food, whether it be vegetable or animal.

2nd. Exercise does not cause a very marked increase in the sulphates.

3rd. Sulphuric acid when taken in large quantity increases the sulphates in the urine. In small quantity, even when long continued, no effect is manifest.

4th. Sulphur when taken does increase the sulphates in the urine.

5th. Sulphate of potash and sulphate of magnesia produce the most marked increase of the sulphates in the urine.