THESIS

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by

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PERTUSSAL GLUCOSURIA with observations on the Reduction of Fehling's Solution by the Urine in Childhood.

The observations which I purpose to record in the present thesis were commenced about twelve years ago, their primary object being to investigate the existence as well as the characters of that condition occasionally referred to in medical literature under the name of "Pertussal Glucosuria." From this main subject, however, I have been compelled to extend my observations over a much wider field so as to bring within their scope the conditions presented by the urine in a large number of diseases other than pertussis, with the object of throwing light on the true character of the so-called "Glucosuria" of Whooping Cough. The attention of the medical profession was first directed to the reducing power of the urine in Whooping Cough upon copper salts by Dr. Gibb of

London, in a paper on the "Pathology of Saccharine Assimilation," published in the Lancet in 1855. In this paper Dr. Gibb gives no details but contents himself with stating that sugar "is occasionally present in the urine of Whooping Cough, both in its simple and complicated forms." In a letter to the Lancet of 1858 Dr Gibb confirms his previous observation and refers to the remarkable effect of nitric acid in bringing about the disappearance of the sugar from the urine. In the same publication (Vol. I, 1858, p. 120) there is a further reference to "Pertussal Glucosuria" among the "Clinical Records." A corroboration of Dr. Gibb's observation is also published at p. 302 of this volume by Dr. Johnston of Birmingham, who, however, while admitting the presence of sugar in the urine of Whooping-Cough patients, does not consider it peculiar to the disease, much less does he think it the cause of the affection. In his opinion, sugar is present in the second and third stages of nearly every case of Whooping-cough, while it is absent in the first. Like Dr. Gibb, this observer gives

no details of observations. With the exception of a few general references to the subject scattered through the text-books devoted to Diseases of Children, I have been unable to discover any further references either in general terms or in detail. Dr. Pepper of Philadelphia has likewise failed to discover any literature on this subject beyond what has been quoted here.

The practical absence of detailed observations upon a subject which appears to have created a considerable amount of interest when first enunciated by Gibb and Johnston is probably due to the fact that Whooping-cough, while, it is excluded from general hospitals on account of its infectious nature, is not commonly admitted to such hospitals as are devoted exclusively to the reception of zymotic diseases, on account of its generally accepted trifling character. As a result, opportunity for long continued and detailed observation is wanting. In the city of Glasgow Fever Hospital at Belvidere, however, considerable accommodation is provided for the isolation and treatment of Whooping-cough cases

and here a large amount of material is available. In the wards of this institution my observations were commenced, but as collateral points and side issues had to be followed up and experiments on doubtful points extended and corrected, I was compelled to draw my material from other sources, and the Western Infirmary, the Royal Hospital for Sick Children, the Kennedy Street Fever Hospital, and the Small-Pox Hospital, were all laid under contribution.

At first sight it would appear a comparatively simple matter to place upon record a series of observations demonstrating the existence of "Pertussal Glucosuria," but when we consider the difficulties which beset the usual tests for glucose and more especially Fehling's test; when we have to decide whether the reducing action on Fehling's solutions of the urine of those suffering from Whooping-cough is peculiar to that disease, or is possessed as well by urine derived from other diseases, as well as from healthy children, and when we have to decide the nature of the substance

present in the urine which confers upon it the power of reducing Fehling's solution, the extent of the subject will be better appreciated.

From what has been said it will be obvious that the observations about to be recorded aim at the solution of the following questions:-

I Has the urine of persons suffering from Whooping-cough a reducing action upon Fehling's solution, and if so, is this reducing action a constant one, and what are the relations to the phases of the disease?

II Is this reducing action of the urine in Whooping-cough peculiar to that disease, or does urine from children suffering from other diseases possess a similar reducing power?

III In event of this reducing action being possessed by the urine of children suffering from diseases other than Whooping-cough, is this reducing action <u>greater</u> in Whooping-cough than in those other diseases?

IV Is this reducing power possessed by the urine of healthy children?

V What is the nature of the substance or substances which confers upon the urine of childhood this reducing power?

VI If the reducing substance be sugar, to what cause is its presence in the urine of Whooping-cough patients due?

period of - say 24 hours, a deposit of hydrated suboxide of copper forming a yellow spot varying in size according to the extent of the reduction will be found at the bottom of the test tube, while the upper part of the fluid continues opaque and milky. The substance in the supernatant fluid deposits very slowly and may continue suspended for many days. This may be mistaken for earthy phosphates, but that it is due to the presence of glucose may be readily demonstrated by fermentation when the power of producing this reaction is lost by the urine, so treated. This method of determining the presence of suboxide of copper only after the lapse of 24 hours was the result of experience, as I found that a much larger proportion of the urines examined after that period gave evidence of reduction than when the contents of the test tube were examined on complete cooling - say at the end of 1 to 2 hours. It might be objected that this method is open to fallacy, and that changes might be produced in the test solution by substances other

than sugar present in the urine, as a result of prolonged contact; but I shall endeavour to show in a subsequent part of my paper that this objection is entirely unfounded. The importance of allowing the mixed fluids to stand for so long a period as 24 hours will be evident if we take into considerstion the high specific gravity 1.162 of Fehling's solution, which even when mixed with a proper proportion of urine reaches 1.104, and the extremely fine state of subdivision in which the precipitated suboxide exists. The milky appearance presented by Fehling's solution on the addition of a minute quantity of glucose-containing urine, is quite characteristic, but can be distinguished from earthy phosphates only after long experience in working with the test; but the deposition of hydrated suboxide of copper after some hours will enable those who have had comparatively little experience with Fehling's solution to at once detect even the slightest reduction. The importance of this method may be readily demonstrated by shaking up

the contents of a test tube, shewing a slight reduction when it will be found that the suboxide recollects at the bottom of the tube very slowly, occasionally only after an interval of several hours. The milky appearance above referred to is not invariably present even when the reducing agent is glucose, for sometimes the supernatant fluid is free from suspended particles and quite transparent, the suboxide forming a well-defined patch at the bottom of the test tube. When a urine contains a mere trace of glucose, reduction occurs very slowly even in the presence of a great excess of the test fluid, and this fact also makes it a matter of importance not to decide upon the presence or absence of sugar till after the lapse of some hours. When the reducing action of a urine depends upon the presence of a minute quantity of glucose the resulting suboxide is, so far as my experiments go, invariably yellow and <u>never</u> red. This point is in itself one of great importance as the precipitate which results from the

reduction of Fehling's solution by other substances is mostly unlike this varying in colour from a brick-red to purple, or even vermilion, the last colour occasionally being produced by prolonged heating of even freshly prepared test fluid. The following table which gives the mean results of a number of experiments intended to bring out the gradual precipitation as well as the colour of the suboxide will prove of interest. The first series of experiments was carried out in aqueous solutions of glucose of varying degrees of strength, while in the second series of experiments normal urine was substituted for the water. In every case 3 C.C. of solution of glucose were treated with 4 C.C. of Fehling's solution.

Glucose %	Solution in Water	Glucose %	Solution in Urine.
1	Immediate brick-red ppt.	1	Immediate yellow ppt.
0.5	Immediate brick-red ppt.	0.5	Immediate yellow ppt.
0.25	Immediate brick-red ppt.	0.25	Immediate yellow ppt.
0.125	Brick-red ppt. after 1 min.	0.125	Yellow ppt. after 1 min.
0.0625	Brick-red ppt. after 3 min. supernatant fluid almost clear	0.0625	Yellow ppt. after 3 min.
0.031	Purplish deposit at bottom of test tube in 5 min. supernatant fluid slightly turbid	0.031	Yellow ppt. on becoming quite cold
0.016	Very slight deposit when the contents of the test tube were nearly cold.	0.016	Yellow ppt. on becoming quite cold.
0.008	Minute trace of deposit when the urine was quite cold	0.008	Slight yellow ppt. after 12 hours.
0.004	Very slight ppt. after 6 hours	0.004	No reaction after 24 hours
0.002	No reaction after 24 hours	0.002	No reaction after 24 hours
0.001	No reaction after 24 hours	0.001	No reaction after 24 hours.

It will be seen from this table that glucose in its interaction with Fehling's solution behaves differently in some points according as it is dissolved in water or in urine. The reactions appear practically the same except in point of colour until the solutions are reduced to a strength of 0.031 % when we find the aqueous solution giving a more marked difference to the colour of the resulting suboxide, viz., a purplish rather than red tint which is maintained through all the subsequent degrees of dilution, while the precipitate deposited by the urinary solution of glucose is, without exception, bright yellow. In the second place, while the aqueous solutions of glucose precipitate the suboxide with great rapidity in most instances leaving a clear supernatant fluid, the urinary solutions when they contain a comparatively small quantity of glucose deposit the suboxide much more slowly, leaving it may be for many hours or even for several days a milky and very opaque supernatant layer, which deposits very slowly.

These facts furnish a rough method of estimating approximately the quantity of glucose present in a sample of urine when the former does not exceed .25%, because any urine which contains less than that amount shews no signs of reduction until it has been allowed to stand for some little time, and also indicates a ready method by which one may gauge the intensity of reducing power possessed by a sample of urine. In future I shall speak of those reductions which take place while the test is being performed as "immediate" reductions, while those which take place after some little time and which indicate less than 0.25% of glucose as "remote" reductions. Though the bulk of the experiments were carried out as just described, it was occasionally inconvenient to employ a water bath for heating the tubes, and under these circumstances the usual method of heating over a spirit lamp or Bunsen flame was employed, care being taken that the contents of the tube were elevated to the boiling point and immediately removed from contact with

the flame.

All urines were examined for evidence of reduction immediately on the test being carried out as well as at the end of 24 hours:

In deciding the nature of the substance or substances present in the urine which conferred upon it the power of reducing Fehling's solution, with the separation and precipitation of cuprous oxide, the fermentation test had to be employed very extensively.

This test, when used for the detection of minute quantities of sugar, requires to be carried out with the greatest possible care on account of certain fallacies with which it is beset. In the first place, urine when passed even without coming into contact with the air contains something like 15 volumes per cent. of gas which may be readily collected by the mercurial pump, or less completely by merely heating the urine. This amount is increased when the urine is passed in the usual manner and allowed to stand in contact with the atmosphere. This gas is still

further increased in amount when the urine contains even a minute quantity of sugar as a result of the spontaneous fermentation which the urine undergoes under such circumstances. In the second place, the yeast, whatever variety be used, almost invariably contains a small amount of gas in its interestices, as well as traces of sugar clinging to its substance. To prevent fallacy arising from gas derived from these various sources, this gas must be completely got rid of before one is able to draw any definite conclusions from the results of the fermentation test.

The plan usually followed by myself consists in placing the urine to be examined in a small flask capable of holding from 50 to 100 C.C., provided with a long, narrow neck having a capacity of from 3 to 4 C.C. To this a tube provided at the upper end with a thistle funnel of considerable capacity is fitted by means of a perforated rubber stopper, so that the lower end reaches to the bottom of the flask. This flask is filled to the

lip with the urine to be examined and the stopper inserted in such a way that all air is excluded and the urine lies in accurate contact with the stopper. The displaced urine rises into the funnel. The whole is then plunged into a pan of water and boiled until gas, which after a few minutes collects in considerable quantity, ceases to be evolved. The flask and contents are then allowed to cool when the gas is permitted to escape by loosening the stopper. The apparatus is now ready to receive the yeast. This latter is prepared by breaking up either dry or compressed German yeast into small particles, placing them in a beaker with pure water and exposing for 24 hours in a water oven at a temperature of from 30° to 35° C. As a result of this proceeding any sugar clinging to the substance of the yeast is completely destroyed and all gas in its interstices is got rid of. The yeast, after being thus treated, is washed in repeated changes of tepid water till the washings cease to give an acid reaction to litmus paper.

Yeast so prepared may be kept for several days under water and is entirely pure and free from objection as a test medium, as may be demonstrated by placing a little in freshly boiled distilled water, and exposing on a water bath for 24 hours. On boiling it as above directed no gas will be evolved.

A little of this yeast, the amount depending upon the quantity of urine to be fermented, is then placed in the flask prepared as above, and the whole exposed in a water oven and maintained at a steady temperature of 30° to 35°C. for 24 hours, though in some cases 36 hours may be allowed. Care, however, must be taken that the fermentative process is not carried on for too long a time, as putrefactive changes will occur in the urine and in the yeast, and gas will be evolved as a consequence. After the lapse of at least 24 hours the flask, if no accumulation of gas is apparent in the neck, must be again placed in boiling water and kept at the boiling point for half an hour or

longer when the gas in solution will be driven off and collect in the narrow neck, part of the fermented urine being displaced into the bulb of the thistle funnel. The amount of gas should be examined after complete cooling of the apparatus and may be proved to be carbon dioxide by testing with lime water. If the urine should contain no sugar and if the test be carried out as directed, absolutely no gas will be given off. In conducting the fermentation test for the detection of minute quantities of sugar, boiling after fermentation is absolutely essential in view of the fact that at a temperature of 60°F urine is capable of dissolving about its own volume of gas. In mixing the prepared yeast with the urine, agitation of the contents of the flask must be carefully avoided. If the neck of the flask be graduated the amount of gas may be used as a somewhat rough method of estimating the quantity of sugar.

The fermentation test carried out as described is one of extreme delicacy and, as will be seen

from the following table, is capable of detecting very minute quantities of sugar either in water or in urine.

Per centage	Sol. of Glucose in Water	Sol. of Glucose in Urine.
1	Free evolution of CO_2 after 48 hours	Free evolution of CO_2 after 48 hours
0.5	Slight evolution of CO_2 after 48 hours	Slight evolution of CO_2 after 48 hours
0.25	No CO_2 after 48 hours but evolved freely on boiling	No CO_2 after 48 hours but evolved freely on boiling
0.125	CO_2 evolved on boiling	CO_2 evolved on boiling
0.063	Small amount of CO_2 evolved on boiling	Small amount of CO_2 evolved on boiling
0.032	Small amount of CO_2 evolved on boiling	Small amount of CO_2 evolved on boiling
0.016	No reaction and no evolution of gas on boiling	No reaction and no evolution of gas on boiling.

The results of actual experiments upon weighed quantities of anhydrous glucose given in this table bear out the theoretical results when the solubility of carbonic anhydride in water is remembered, that solubility making it impossible that gas should be evolved at ordinary temperatures with quantities of glucose less than 0.5%. The value

of heating the fermented fluid and the delicacy of the test when properly applied will be seen from the table. The fermentation test may be rendered more delicate for the detection of minute quantities of sugar by concentrating the suspected urine and filtering before submitting it to the fermentative process. Concentration seems to interfere little or not at all with the activity of the yeast.

Another method of applying the fermentation test consists in evaporating the urine to a small bulk by boiling, then filtering while hot. This gets rid of any coagulable substance such as albumen, which may be present. The filtered urine is then evaporated to dryness on a water bath and the residue treated with boiling alcohol, filtered and again evaporated to complete dryness. The final residue is then treated with warm water and fermented as already described. When performing the yeast test it is always well to prove the activity of the yeast by fermenting it with a solution of glucose in water. The effect of fermentation in destroying sugar may be used as a control test, the

urine after fermentation and filtration being tested with Fehling's solution when no precipitation of cuprous oxide will take place. The rapid increase in the acidity of saccharine urines with fermentation and the comparative absence of acidity in those which do not contain sugar is very noticeable, and can be readily demonstrated in the former case by almost neutralising the urine with dilute solution of sodium carbonate, and testing with litmus paper after fermentation. The amount of gas accumulated above the surface of the urine fermented with the already mentioned precautions may be employed to roughly estimate the amount of sugar. As will be seen from the table anything less than 0.5 per cent. of sugar will not cause an evolution of free carbonic acid, so that when gas is evolved during the process of fermentation the quantity present must be greater than that mentioned.

The Reducing Power of the Urine in Whooping-cough.

Having considered the available literature on "Pertussal Glucosuria" and the chemical methods adopted in these investigations, I shall now proceed to explain the routine followed in collecting the samples of urine, confining myself for the present to the urine of the Whooping-cough patients. The reducing power of the urine in the disease under consideration was investigated in sixty-six cases of which thirty-two were male and thirty-four female patients. The ages ranged from seven months to ten years. In twenty of the cases every sample passed by the patients under observation was examined, and occasionally as many as eleven samples from a single patient were tested in the course of the day. In the remaining forty-six cases two or sometimes three samples only were examined, one at 8 a.m., while the patient

was fasting, and a second at 8 p.m., representing the urine during digestion. When a third sample was collected it was taken about noon. My object in examining every sample in the first set of cases was to determine if possible the relation of the reducing power of the urine to the "whoop" and cough; but the amount of labour this involved to the nurses compelled me to abandon it after the completion of the first twenty cases. The period of residence of the patients in hospital extended from three weeks to three months, so that the number of samples examined in different cases varied considerably, the greatest number tested in any one patient being 385. In the course of my remarks I shall use the words "night" and "day" to denote the periods embraced between 8 p.m. and 8 a.m., and between 8 a.m. and 8 p.m. respectively.

In all, 6,650 samples of urine were examined, or an average of 101 from each patient. Of these 4,490 or 68% gave no evidence of "immediate" re-

ducing power on testing, while 2,160 or 32% gave very decided and "immediate" evidence of reducing power, during the process of testing. I would especially emphasize this point because a careful distinction must be drawn between the reducing power of the urine as manifested before cooling - it is to such reductions I have applied the term "immediate," - and the same power as manifested by the precipitation of suboxide of copper after cooling or standing for several hours, which I have termed "remote reduction." Of the total samples 3,400 or about 50% deposited suboxide on standing for 24 hours. The difference of time occupied in the separation and precipitation of the suboxide means a difference in amount or intensity of reducing power which must be borne in mind when comparing the extent of the reducing power of the urine in Whooping-cough with that found in the urine of diseases other than Whooping-cough, because this difference shews a variation in the quantity of the substance or substances to which

the urine owes its power of reduction. While the "immediate" reducing power of the urine in 32% of the patients examined was very decided and often extremely well marked, the appearance of the precipitate sometimes resembling that got with true diabetic urine, yet in few of the samples subjected to volumetric analysis did I find more than a reducing power such as would be represented by a 1% solution of glucose, i.e., about 4½ grains per ounce. In the great majority of samples it was much less than this, and in many cases an accurate estimate of the reducing power was scarcely possible. In no case was the specific gravity markedly affected and in none did the urine suggest diabetes. In future when discussing reductions in Whooping-cough I shall refer to "immediate" reductions only.

The proportion of urines possessing "immediate" reducing power to the total samples examined in any individual case varied within wide limits; in some of the cases almost every sample giving a reaction with the test solution, while in others the pro-

portion fell as low as 9%. Not only did the reducing power vary in individuals but it also varied in the same individual from day to day.

Before proceeding to analyse the various stages of Whooping-cough in their relation to the reducing power of the urine it will be best to discuss the more general features of the subject taking eighteen out of the total cases as examples. This will enable me to deal more readily with the statistical side of the question, as I shall in this way avoid an unwieldy mass of figures which would prove cumbersome and difficult to deal with and would obscure the subject rather than render it clearer. These eighteen cases have been selected from the others on account of their freedom from complication and will be used to illustrate the subject throughout.

The following table gives a general view of the number of samples examined in these cases with the proportion of those shewing "immediate" reducing power as compared with those in which no such power was manifested. The relation of the reduc-

ing power of the urine to the severity of the attack is shewn in the last column.

No.	Total Samples	Reducing	Not Reducing	Proportion of Reductions	Type of Case
1	95	55	40	58. %	Severe
2	110	22	88	20. %	Mild
3	34	14	20	41. %	Severe
4	83	27	56	32.5%	Moderate
5	234	158	76	67.5%	Very Severe
6	155	67	88	43. %	Severe
7	383	131	252	34. %	Moderate
8	229	111	118	48.5 %	Severe
9	228	80	148	35. %	Mild
10	245	94	151	38.4%	Moderate
11	203	38	165	18.5%	Mild
12	220	75	145	34. %	Moderate
13	142	13	129	9.7%	Very Mild
14	328	176	152	53.7%	Very Severe
15	97	20	77	20.5%	Mild
16	132	76	56	57.5%	Severe
17	58	32	26	55. %	Severe
18	62	22	40	35.5%	Mild

An examination of this table will shew:-

1st. How large a proportion of the urines examined gave an "immediate" reduction.

2nd. That the reducing power varies enormously in the different cases, the proportions ranging from 67.5% down to 9%.

3rd. That the proportion of urines manifesting "immediate" reducing power is directly as the severity of the attack.

These facts will be generally borne out by an examination of Table I in the appendix where details of all the observations made are given. In an investigation such as the present the question whether the dietary of the patient may not be to some extent responsible for the reducing power of the urine naturally suggests itself. The dietary in practically all the cases was very similar consisting of milk and farinaceous food with a comparatively small amount of meat. While it is obvious that the dietary will influence the whole of the urine passed in each period of twenty-four hours, yet we would expect to find its influence upon the urine more marked during the day than during the night. This point must be borne in mind when we come to discuss the influence of the diet upon the reducing power of the urine in Whooping-cough, as compared with other diseases. In the following table an attempt is made to show the influence of night and day upon the reducing power of the urine. In the first section the urines

examined were those of children in whom the digestive processes and absorption were carried on actively, while in the second section fasting urines only are dealt with. The first column of each section shews the number of urines in which no reduction was obtained, and the second the number of urines in which reducing power was manifest. The third column gives the total urines passed in each period of twelve hours. The proportions of reductions during the day and night are compared in the last column of the table.

	Day			Night			Proportion %	
No.	No Reduction	Reduction	Totals	No Reduction	Reduction	Totals	Day	Night
1	24	30	54	16	25	41	56	61
2	41	12	53	47	10	57	22.6	18
3	8	8	16	12	6	18	50	33.3
4	32	15	47	24	12	36	32	33.3
5	38	80	118	38	78	116	67.5	67
6	53	30	83	35	37	72	36	51
7	128	78	206	124	53	177	38	30
8	68	45	113	50	66	116	40	59
9	80	29	109	68	51	119	27	43
10	104	44	148	47	50	97	30	51
11	106	17	123	59	21	80	14	26
12	107	32	139	38	43	81	23	53
13	86	5	91	43	8	51	5.5	15
14	106	78	184	46	98	144	42	68
15	39	10	49	38	10	48	20	20
16	25	41	66	31	35	66	62	53

	Day			Night			Proportion %	
No.	No Reduction	Reduction	Totals	No Reduction	Reduction	Totals	Day	Night
17	12	18	30	15	14	29	60	49
18	21	8	29	19	14	33	27	42

On comparing the figures in the last double column it is evident that though the proportions between "day" and "night" reductions are quite inconstant, yet the figures shew a reducing power decidedly in favour of the fasting urines, and on working out the mean of these proportions it is found that the reductions during day and night are as 37 to 42, the preponderance being in favour of the fasting urines. This fact, so far as it goes, is decidedly against the suggestion that the reducing power of the urine is the outcome of dietetic conditions, for,, as already hinted, if it were so we would expect the reductions to be more frequent and intense while the processes of absorption and assimilation are most active.

It may be suggested, however, that although

the urine from fasting Whooping-cough patients shews a more frequent reducing power than that from the same patients while digestion is active, yet that this is merely the "tailing off" of the more active reduction present during the day as shewn by a greater instead of a more frequent precipitation of suboxide. The accompanying table bears on this point and is intended to shew the relation between the urine passed during the day and night periods, and the reducing power as indicated by the quantity of suboxide precipitated. A = abundant; C = considerable; D = distinct; Tr. = trace, and M.tr. = Minute trace. The proportions are in percentages.

No. of Case	Abundant		Considerable		Distinct		Trace		Min. Trace	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
1	0	0	5.5	0	11	20	18.5	25	11	9
2	0	0	0	0	13.6	13.6	18	18	13.6	23
3	0	0	0	0	7	14.5	14.5	43	21.5	0
4	0	0	0	0	25.9	37.1	14.8	19	3.7	0
5	0	0	0	0	29	28	16.5	17.7	3.8	5
6	0	0	0	0	15	17	26	21	8.	13
7	0	0	0	0	12.5	28	17	23.5	8.5	10.5
8	0	0	0	0	205	24	16.5	25	3.6	10.4

No. of Case	Abundant Day	Abundant Night	Considerable Day	Considerable Night	Distinct Day	Distinct Night	Trace Day	Trace Night	Min. Trace Day	Min. Trace Night
9	0	0	0	0	2.5	10	15.	36	18.5	18
10	0	0	4.3	1.1	20	13	18	23	5.5	17
11	0	0	0	0	8	18.5	18.5	26.5	18.5	10
12	0	0	0	2.6	17	30.5	20	17	5	8
13	0	0	15	0	0	30	15	15	10	15
14	0	0	0	2	14	23	20	22	10	9
15	0	0	0	0	5	0	20	30	25	20
16	0	0	6.5	6.5	14	9	18	29	6.5	9
17	0	0	0	0	6.5	19.5	19.5	42	9.5	3
18	0	0	0	0	0	4.5	27	45	9	14.5

A glance at this table will make it clear that there is no constant relation as regards the intensity of the reducing power so far as it can be gauged by the amount of suboxide precipitated in the urines passed during periods of fasting or otherwise. Examining the individual columns we find that the figures in each stand as follows:-

	Day	Night
"Considerable"	7.8	3.1
"Distinct"	14.2	20
"Trace"	18.5	26.5
"Minute Trace"	10.6	12

Here we have it demonstrated that the reducing power of fasting urine is decidedly greater than that of urine passed during active digestion,

except in the case of the first column "Considerables" where, however, the number of reductions is too small to warrant our drawing any definite conclusions. Excluding then the "Considerables" from our consideration and comparing "day" column of "Trace" with the "night" column of "Distinct" and the "day" column of "Minute Trace" with the "night" column of "Trace" (see preceding Table), we find the figures stand thus:-

Night		Day	
Distinct	20.	Trace	18.5
Trace	26.5	Min. Trace	10.6

This comparison of the reducing power of the fasting or "night" urine with that of the succeeding period of active digestion shews strongly in favour of the greater intensity of the reducing power of the former. It thus becomes evident that fasting urines of Whooping-cough possess not only a more frequent, but also a more intense reducing power than those of active digestion.

Among the sixty-six cases of Whooping-cough

investigated there was one in whom there was no indication of a "whoop" throughout the whole course of the attack, so that it became impossible to separate the stages of the illness. This case was an extremely mild one. From it 157 samples of urine were examined of which 63 were fasting urines and 94 were collected during the day. "Immediate" reductions were given by 24 or 15.3% of the whole; and none of the reductions indicated a marked intensity of reducing power, 58% of these being recorded as shewing only a trace of suboxide.

Before passing from the consideration of the general features of my subject, it may be of interest to give a brief summary of a case which came under my notice suffering from Whooping-cough, and two years later with Varicella. The condition of the urine of this child while suffering from the former disease, was very striking when compared with that while suffering from Varicella. During the course of its first illness no less than 69.5% of the samples examined gave "immediate" reduction

while during the attack of chicken-pox 52 samples of urine were examined of which only 3 or about 6% gave "remote" reductions, and even these were indicated by the presence of only a minute trace of suboxide. The diet of this child was practically the same during both periods of its residence in hospital.

Passing now from our discussion of the more general points associated with the reducing power of the urine in Whooping-cough, the influence of the various stages of the disease on this power now falls to be considered. For obvious reasons, but little opportunity was afforded for examining the urine during the first or catarrhal stage, but in the case of four of the children who came under observation when the disease was merely suspected, owing to other members of the family suffering from fully developed and typical attacks, this opportunity was presented. In all four "immediate" reducing power was manifested, the extent of which will be best appreciated by a reference to the

subjoined table which shews the number of samples examined during the catarrhal stage with the proportion of urine possessing "immediate" reducing power.

Case	Samples	Reduced	Per Cent.
1	20	4	20
2	23	3	13
3	25	9	36
4	41	23	56

From this it will be seen that during the catarrhal stage the urine does possess reducing power of sufficient intensity to produce an "immediate" precipitation of cuprous oxide in 39 of the 109 samples examined or a mean proportion of nearly 36%.

Leaving the observations on the second or "convulsive" stage for future discussion, it will be most convenient at this point to give details of the reducing power presented by the urine during the third stage or that of "resolution." Here we have abundant material on which to base our conclusions. In one case of great severity the child was removed from hospital and was lost to observa-

tion before the completion of the second stage of the attack, and as already mentioned, it was impossible in one case to discriminate between the different stages of the illness on account of the absence of "whoops." This leaves us with 64 cases in which it was possible to note the condition of the urine during the stage of convalescence. Taking into consideration only the cases in which the end of the convalsive stage was moderately well defined, we find that of the urine passed during this period, i.e. between the complete cessation of "whoop" and dismissal from hospital, 25% gave evidence of reducing power capable of causing an "immediate" precipitation of cuprous oxide on heating with Fehling's solution. It would serve no good purpose to give here a detailed list of the conditions of the urine in every case during this stage - these will be found in Table I, (in appendix), and in the accompanying table I shall again consider the condition present in the urine of those eighteen cases, which I have already discussed in the earlier part of this section.

No.	Total Samples	Total Reducts.	Proportion	No.	Total Samples	Total Reducts.	Proportion
1	39	10	25.6%	10	70	36	51.5%
2	60	5	8.4%	11	91	26	28.5%
3	29	4	13.4%	12	71	10	14 %
4	32	5	22.7%	13	39	10	25.5%
5	21	15	71 %	14	113	9	8%
6	101	54	53.5%	15	14	8	57%
7	101	36	35.6%	16	25	5	20%
8	221	34	15.8%	17	38	22	58.5%
9	156	39	25 %	18	28	11	39%

The figures here detailed afford a fair sample of all of the cases investigated. It will be observed on reference to the table that the proportion between the number of urines shewing reducing power, and those which did not possess this power varied within wide limits, viz., from 8 to 71% and in general it may be said that these proportions were a direct index to the severity of the attack, case 5 in Table being a very severe one, while case 14 was of the mildest possible type, a "whoop" having been present for only some three days. Case 6 is an example of a patient detained a long time in hospital on account of the continuance of the cough, and from whom a very large number of samples were examined during the stage of "resolution,"

no less than 53.5% of them shewing reducing power in a very high degree.

The mean of the proportions of "reducing" to "non-reducing" urines in this stage as set down in the foregoing table, is 27%.

Passing now to a consideration of the condition of the urine in the second or "convulsive" stage, we find that by far the greatest reducing power was manifested by the urine during this period. Taking the mean of 64 cases in which this period was tolerably well defined 49% of all the samples tested exercised an "immediate" reducing action upon Fehling's solution. This fact is well brought out in the subjoined table, a glance at which will show, that, as in the stage of "resolution"

No.	Total Samples	Total Reducts.	Proportion of Reducts.	No.	Total Samples	Rotal Reducts.	Proportion of Reductions
1	56	45	80%	10	152	68	44.7%
2	50	17	34%	11	136	28	20.6%
3	19	13	68%	12	181	65	36 %
4	62	12	19.5%	13	29	4	14 %
5	133	104	78.2%	14	339	165	48.5%
6	54	8	14.8%	15	27	10	37. %
7	162	97	60 %	16	49	12	24.5%
8	73	72	98.5%	17	70	46	65.7%
9	163	44	27 %	18	31	21	68. %

the reducing power of the urine varied greatly in different patients, the highest reducing power being shewn by case 8 with 98.5% of reductions, and the lowest by case 13 with only 14%. The reducing power of the urine in this stage, however, is at once seen to be much greater than in either the first or third stages, the sequence of proportions being 46.5, 36, and 27% respectively. A comparative view of the reducing power of the urine in the various stages of the disease in the eighteen cases already analysed is given in the accompanying table, from which it will be seen that

No.	Catarrhal Stage	Convulsive Stage	Resolvent Stage	No.	Catarrhal Stage	Convulsive Stage	Resolvent Stage
1	-	80	25.6	10	-	44.7	57.5
2	-	34	8.4	11	-	20.6	28.5
3	-	68	13.4	12	-	36.	14.
4	-	19.5	22.7	13	-	14	25.5
5	-	78.2	71.	14	-	48.5	8.
6	20	14.8	53.5	15	13	37	57.
7	-	60	35.6	16	36	24.5	20
8	-	98.5	15.8	17	56	65.7	58.5
9	-	27.	25	18	-	68	39.

while the averages of the reducing urine in the three stages are as stated above, viz., 36 in the

catarrhal, 46.5 in the convulsive, and 27 in that of resolution, yet when we examine the individual cases we do not find this order invariably maintained as we might expect if the reducing power is to be considered a characteristic feature of the convulsive stage, and due to conditions peculiar to this period of the illness; for we observe that while in twelve of the patients the urine during the convulsive stage possessed greater reducing power, in five, this power was greatest during the stage of resolution and in one during the catarrhal stage. From this it is evident that the reducing power cannot be the result of conditions present only during the convulsive stage of whooping-cough, and it follows that this reducing power is not to be considered as the result exclusively of such phenomena as are present during this stage, that is to say of the greater or less degree of venous obstruction produced by the respiratory convulsion, nor yet to any other condition associated with the "whoop" except in so far as the severity of the convulsive stage direct-

ly measures the gravity of the whole attack; and though it is difficult to demonstrate this graphically, yet there seems to be little doubt that the more severe the attack the greater is the reducing power of the urine in all its stages. With a view to the elucidation of this point, however, a number of careful observations were made to determine whether there existed any direct relation between the coughs associated with "whoops" as distinguished from those without the "whoop" and the reducing power of the urine. An attempt has been made to illustrate this relationship in the accompanying scheme, but it is obvious that for physiological reasons it is impossible to determine the immediate effect of a "kink" upon the reducing power of any given samples of urine. This scheme gives details of eight cases in which careful notes of the coughs with and without "whoop" were made during each period of twenty—four hours, and its object is to demonstrate as far as possible any association between the "whoop" itself, and the reducing power of the urine. The first column "day" refers to

the day of observation, not to that of illness; and under each case the four columns give, 1st. the number of whoops (W); 2nd. the total coughs (C); 3rd. the number of urines shewing reducing power (R) and 4th. the total number of samples examined during the corresponding period of 24 hours.

Cases I, II, III, and IV.

Day	Case I				Case II				Case III				Case IV.			
	W	C	R	T	W	C	R	T	W	C	R	T	W	C	R	T
1	3	8	4	4	6	14	1	1	16	21	1	2	6	6	4	8
2	0	11	1	4	41	60	2	6	19	24	3	4	9	10	1	8
3	0	9			26	31	3	5	19	24	2	4	8	8	-	5
4	0	9	3	7	25	30	2	5	12	19	2	3	8	10	2	5
5	0	4	2	5	18	25	-	1	13	17	4	4	7	9	1	7
6	0	5	2	4	19	25	1	3	14	20	1	4	7	7	1	8
7	0	2	3	3	20	22	3	6	9	12	2	2	8	8	2	5
8	0	3	4	4	14	20	-	4	3	7	3	4	8	8	4	7
9	0	4	3	6	14	18	1	3	5	10	-	4	4	4	2	2
10	0	2	2	5	21	28	1	3	10	16	4	8	11	13	5	7
11		0			11	19	1	1	6	9	3	4	7	8	1	7
12					10	15	5	5	10	15	2	2	6	6	2	6
13					8	12	3	4	8	17	1	5	7	11	2	6
14					10	17	2	3	6	13	4	5	7	8	2	8
15					7	10	3	7	7	10	3	4	10	12	1	5
16					15	19	3	5	8	11	3	4	7	12	-	4

Cases I, II, III, and IV. Contd.

Day	Case I				Case II				Case III				Case IV.			
	W	C	R	T	W	C	R	T	W	C	R	T	W	C	R	T
17					13	15	4	7	4	8	-	-	0	2	-	9
18					9	11	4	5	1	4	-	-	0	0	-	5
19					8	10	2	4	5	6	2	2	1	3	5	9
20					10	12	-	-	1	2	5	5	0	2	-	7
21					10	12	-	-	3	4	4	4	5	5	-	7
22					9	13	2	2	0	1	6	6	0	2	2	8
23					10	10	6	6	0	1	4	8	1	2	2	8
24					7	12	3	3	0	0	10	11	0	2	1	8
25					7	9	5	5	0		7	12	0	2	1	8
26					6	12	7	8					2	5		
27					5	10	2	9					4	5		
28					2	2	6	10					0	0		
29					7	11	7	12								
30					5	9	5	8								
31					5	8	2	3								

Cases V, VI, VII, and VIII.

Day	Case V				Case VI				Case VII				Case VIII			
	W	C	R	T	W	C	R	T	W	C	R	T	W	C	R	T
1	13	13	4	4	13	13	3	3	32	32	3	4	8	8	1	1
2	24	24	5	8	14	16	5	6	27	27	6	6	9	11	1	1
3	20	20	5	10	16	19	6	9	24	24	6	6	5	9	2	4
4	10	10	4	9	13	15	-	3	21	21	1	3	1	3	-	8
5	15	15	5	6	14	18	-	7	17	17	4	4	3	3	-	8
6	12	12	5	9	16	18	2	9	15	15	8	8	0	5	-	7
7	11	11	1	4	10	14	3	3	13	17	4	9	0	0	-	9
8	14	15	6	7	7	9	-	8	9	9	2	3		1		
9	10	11	3	10	7	9	1	4	10	10	3	8		0		
10	10	11	2	3	9	12	1	5	8	9	1	7		0		
11	8	8	1	8	7	10	-	4	5	6	-	6				
12	5	5	-	6	5	9	-	8	6	8	-	6				
13	7	7	-	6	8	11	-	7	3	3	-	7				
14	6	9	-	4	2	3	1	6	7	7	-	8				
15	3	4	-	8	0	0	-	9	6	6	-	7				
16	1	1	2	7	3	4	1	2	5	5	-	7				
17	0	0	2	5	6	7	2	7	5	5	2	2				
18	1	1	-	8	5	7	-	7	5	5	3	7				
19	0	0	2	2	5	10	1	6	6	8	3	7				
20	5	6	6	7	7	8	-	6	14	16	-	4				
21	1	1	6	7	7	7	2	8	11	11	1	8				
22	3	5	6	6	1	7	-	5	10	10	5	8				
23	5	8	3	8	4	10	-	4	12	12	-	4				
24	0	1	4	7	0	0	-	7	4	7	4	5				
25	0	0	2	4	1	1	-	4	0	3	2	9				
26	0	0	2	4	1	3	5	10	0	0	2	5				
27		0			1	1	2	7	2	2	1	9				
28		0			1	2	-	8	4	8	2	7				
29		1			1	1	2	8	1	2	1	8				
30					1	1	1	8	0	0	2	8				
31										0						

An analysis of the figures presented in this table shews that the reducing power of the urine is maintained even after the complete disappearance of the "whoop" as will be apparent on comparing the period of resolution of cases I, III, and V. In all the cases noted except I, IV, and VIII, the number of "whoops" was very great at the commencement of the period of observation. If we except Case VII during the first six days, more than one half of the samples of urine examined shewed no reducing power; and on comparing these again with cases I, IV, and VIII, in which the "whoop" was much less frequent, we do not find that in these the proportion of urines manifesting reducing power was less than in the former. Finally in comparing the earlier periods during which the "whoop" was most frequent, with the later periods when it was much less frequent and less severe, we find the reducing power even more strongly marked in the latter than in the former period as may be seen in case II, 22nd to 26th. day of observation, and in case III from the 18th. to the 24th. day.

From a consideration of these facts it would seem legitimate to conclude that neither the "whoop" apart from the other conditions manifested by whooping-cough, nor the obstruction to the venous circulation which is more marked in cases where the "whoop" is most frequent, can be considered to influence the reducing power of the urine. But though it seems clear that while the "whoop" in itself or the convulsive cough associated with it has no direct connection with the reducing power of the urine, it may be argued that the frequency of the coughs both such as are associated with "whoops" and those which are not, may have some direct influence upon the reducing power. A reference to the foregoing scheme, however, will shew that the number of coughs has no closer association with this reducing power than the "whoops" themselves have. Again, it may be suggested, that any greater reducing power shewn by the "night" urine is the result of the greater frequency of the "kinks" at night as compared with the day. The following table is a record of the coughs in nine

patients who were carefully observed and the coughs recorded by competent nurses who for years had been in charge of whooping cough wards. A separate record was kept of the coughs during the night and day.

Case I		Case II		Case III		Case IV		Case V	
Day	Nt.	Day	Nt.	Day	Nt.	Day	Nt.	Day	Nt.
5	3	4	2	27	33	9	14	11	10
4	7	3	1	13	19	9	12	8	14
7	2	2	0	14	16	9	12	6	11
6	3	2	1	12	13	11	13	9	10
3	1	2	0	13	12	7	12	11	9
2	3	1	0	12	10	5	12	12	8
1	1	0	0	9	11	9	11	11	8
2	1			7	11	4	9	8	4
2	2			14	14	5	2	6	5
2	0			6	8	5	5	16	8
0	0			8	7	8	8	11	6
				8	4	3	6	8	5
				9	8	7	8	12	8
				3	7	5	7	13	5
				12	7	4	8	11	5
				6	9	1	10	12	7
				5	6	7	4	8	5
				3	7	4	4	8	7
				6	6	3	1	14	3
				4	8	3	0	10	5
				8	5	1	1	11	5
				4	6	0	4	9	4
				6	6	1	0	11	6
				3	6	1	0	6	2
				8	4	0	0	4	2
				2	8			6	4

Case VI		Case VII		Case VIII		Case IX	
Day	Nt.	Day	Nt.	Day	Nt.	Day	Nt.
10	14	9	4	15	17	4	7
9	11	12	4	16	11	11	8
11	5	14	5	14	10	6	2
13	2	13	2	14	8	8	3
11	0	13	5	13	4	5	4
10	5	13	5	11	5	3	0
9	2	10	4	9	8	1	2
10	1	5	4	6	3	2	3
6	2	6	3	9	2	0	0
5	0	9	3	7	2	1	0
6	1	9	1	2	5		
8	1	7	2	4	2		
3	1	4	2	1	2		
1	0	2	1	2	5		
0	0	0	0	3	3		
1	0	1	3	5	2		
0	0	7	0	3	2		
5	0	4	3	3	2		
1	0	6	4	5	3		
4	2	6	2	6	9		
5	3	6	1	8	5		
0	1	4	3	5	5		
0	0	8	6	6	6		
0	0	0	0	7	0		
		0	1	0	3		
		0	3	0	0		

The figures here set down support my earlier impression, that in point of fact the symptoms of whooping-cough are not more severe nor the "kinks" more frequent at night than during the day. This

opinion I formed as the result of a long series of observations carried out some years ago, to ascertain the "specific" action of certain drugs in the treatment of whooping-cough. I had occasion at that time to examine this question in close upon 200 cases, and in these no constant nocturnal exacerbation could be demonstrated. The nine cases given in the table are entirely in favour of these former conclusions and shew that while sometimes the "kinks" are more frequent and severe at night, yet just as often the reverse is the case, and there can be but little doubt that in whooping-cough the "kinks" are tolerably evenly distributed between day and night. The suggestion, therefore, that a greater severity of the attacks at night will account for the greater frequency, as well as the greater intensity of the reducing power at this period, cannot be entertained. So far we have discussed the reducing power of the urine in the different stages of whooping-cough, its relation to the whoop, and its daily variations, and now

further points suggest themselves as to the relationship of certain other conditions, such as age and sex to this reducing power. As already stated the ages of the patients ranged from seven months to ten years, and in the following short table these have been arranged in annual groups up to eight years, the last includes the small number of cases from eight to ten years.

Age Period	Proportion of Reductions to total samples.
0-1 yr.	59.5%
1-2 yrs.	No cases
2-3 "	33 %
3-4 "	40 %
4-5 "	53 %
5-6 "	35.5%
6-7 "	35 %
7-8 "	32 %
8-10 "	16 %

The proportion of reductions to the total samples examined at different ages given in the last column of this table would not suggest the existence of any relationship between the reducing power of the urine, and the respective age periods; but, I would call attention to the first age period

with a proportion of 59.5% of "immediate" reductions. The cases represented in this age period were all sucklings, and as will be seen later the urine of such patients usually possesses a high reducing power, so that it is difficult in the present instance to decide how much of that power is traceable to the dietary, and how much to the whooping-cough. While there is no steady fall in the proportion of reductions as age advances, yet there is if anything a tendency in this direction. It is important here to remember that these proportions represent "immediate" reductions only.

Sex would seem to have quite as little influence on the reducing power of the urine as age. It has been already stated there were 32 males and 34 females, and an examination into this point reveals nothing note-worthy, the mean proportion of urines shewing "immediate" reducing power being practically the same in both sexes. We have now completed our investigation into the power of

reducing Fehling's solution possessed by the urine of children suffering from whooping-cough; we have discussed the reducing power in general, its variations in the different stages of the disease, the relations of this power to the cough and "whoop" as well as its variations at different periods of the day, and lastly its relations to age and sex; and consequently we are now in a position to answer in a fairly satisfactory manner the first of the questions with which we set out, viz., "Has the "urine of persons suffering from whooping-cough a "reducing action upon Fehling's solution, and if so "is this reduction a constant one, and what are its "relations to the phases of the disease?" The evidence brought forward so far warrants the conclusion:-

> 1st. The urine of children suffering from whooping-cough both in its simple and in its complicated forms possesses a decided reducing action upon Fehling's solution, this power is not possessed by every sample of urine although 32% of all samples examined manifest a power of causing an "immediate" reduction of the copper solution, or in other words, that that proportion of samples possesses a power of reducing Fehling's solution such as would be represented by a solution of glucose containing 0.25% and

upwards, while about 18% of the samples possess a reducing power less than this.

2nd. This reducing power varies in its intensity and in its frequency of occurrence, but is most markedly developed in the severe cases, being apparently in direct proportion to the gravity of the attack. The reducing action of the urine was at some time present in all the patients examined.

3rd. This reducing power is not present to the same degree in all phases of the illness, being most marked during the convulsive stage and less so in the first and last stages.

4th. The "kinks" except in so far as they are an index of the severity of the attack do not appear to influence the reducing power of the urine either in regard to its intensity or its frequency of occurrences.

5th. Diet would seem, unless in sucklings, to exercise no direct influence upon the reducing power, for fasting urine shows considerably greater activity in this respect than that passed while digestion is active.

6th. The reducing power of the urine being uninfluenced by diet and having no apparent relation to cough, "whoop" or other variable features of the disease, must be regarded as intimately connected with the pathological conditions which produce the diseased state.

This brings us to our second and third questions, viz., "Is the reducing action of the urine "in whooping-cough, which we have been discussing

"peculiar to this disease, or does the urine from "children suffering from other diseases possess a "similar reducing power; and in event of this re- "ducing action being possessed by the urine of "children suffering from diseases other than whoop- "ing cough, is this reducing action greater in "whooping-cough than in those other diseases?"

These questions can be answered only by an analysis of the urine in a variety of diseases peculiar to childhood; and in this connection a series of observations on the urine in the zymotic diseases and others more or less prevalent in the earlier years of life will now be detailed. Of these the first to be delat with is Varicella. This will be followed in detail by Scarlet fever, and Measles, in all of which diseases owing to their segregation in hospital wards it was possible to carry out an extensive series of observations. In other diseases such as those of the heart, lungs, intestinal canal, nervous system, etc., where isolated cases only were available for observation, the

same opportunity of examining masses of cases was not afforded; so that while the records of these cases have been made as extensive as possible they lack that completeness and force of evidence possessed by the first class of cases.

Chicken-Pox.

The reducing action of urine in Chicken-Pox.

(Table II, appendix)

The reducing action of the urine of chicken-pox upon Fehling's solution was investigated in 55 cases. In each case, with a few exceptions, two samples were examined passed about 8 a.m. and 8 p.m. respectively. The period of residence of the patients in hospital varied from 21 to 70 days, so that the number of samples likewise varied; the least number investigated being 17 and the greatest 125 in individual cases, while the average for the whole was a little over 62 samples. Occasionally there was great difficulty experienced in collecting samples at regular intervals from the younger patients.

These 55 cases represent a total of 3,411

samples examined and of these 2,251 or 66% gave no evidence of reduction, whilst 1,160 or 34% gave distinct evidence of reducing power in varying degrees. In only two of the cases examined there was no evidence of reducing power manifested by the urine, while in the individual cases the number of samples shewing reducing power varied from 1 representing 2.3% of the samples examined up to a maximum of 60 representing 60% of the total samples examined in the individual case. The reducing power varied greatly both in the different individuals and also in the same individual from time to time. But though this latter per centage (60) is high, I would here call especial attention to the important fact, that only a very small per centage (3.9) manifested this reducing power, while the test solution and urine were being heated, in this respect shewing a marked contrast to whooping-cough, in which 32% of the samples examined shewed this "immediate" reducing action. Even this small per centage of "immediate" reductions would have

been much smaller but for the fact that in three cases the urine possessed such marked reducing power that the "immediate" reductions in these cases alone represented 1.2% of the total "immediate" reductions among the samples examined. Of the balance of the reductions (31.1%) the reducing activity of the urines was represented in most cases by a mere trace of precipitated suboxide, and that only after the test tube had been allowed to stand for some hours, i.e. these were all "remote" reductions. Another point of interest is revealed by even a cursory examination of table II in appendix, namely, the fact that the reducing power of the urine is manifested at irregular intervals in the course of the individual cases, the samples possessing reducing power being in the majority of instances not scattered uniformly through the period of observation, but grouped together, a single case shewing one or more groups each group being preceded and succeeded by a period of variable length during which the urine shews no trace of reducing power. (see cases 9. 10. 18. 29. 30. etc.) Another point

to be noted is that these groups of urines manifesting reducing power do not by any means coincide with the more acute phase of the illness, but frequently occur towards the end of the attack or even after convalescence has been completely established. (See cases 43 & 45). In the case of those children who were being nursed by their mothers the reducing power of the urine was very strongly marked, practically no day passing while the child was under observation without one, and often both samples examined shewing very marked reducing power. (See cases 6, 15, 25, 41, 44, 48). Bearing in mind that all the cases of chicken-pox observed lived under practically the same conditions and partook of practically the same kinds of food, except of course in the cases of sucklings, cases such as 49, 51, and 54, which were so far as could be ascertained children of average healthy physique, would suggest the question whether some indiosyncracy of nutrition might not be to some extent responsible for the marked reducing power possessed by their

urine.

Going a little more into the details of the cases we find that when these are arranged in age periods we have the following result:-

Age Period	Reductions Per cent.
0-1 yr.	58
1-2 yrs.	39
2-3 "	39
3-4 "	33
4-7 "	28
7-13 "	22

While unwilling to insist too much on these figures, yet they are of interest and strongly suggest that for some reason the urine of very young children would seem to possess a much higher degree of reducing power than that of older children. As already stated the food and surroundings of all the cases observed were practically the same, except in the cases of sucklings, so that the conditions of reduction with reference to age suggested by this table can hardly be attributed to the food, and this point would lead us to

infer the probability of some gradual alteration either in the process of digestion and absorption or of some change in the more obscure and less familiar metabolic processes connected with the liver or general tissues. Sex would seem to make little difference so far as my statistics shew in the reducing power of the urine in chicken-pox, but so far as they go, the figures are in favour of a higher reducing power among males than females. Among individual males the per-centage of reductions varied between 0 and 85, and among females between 0 and 68, while a mean of all the observations gave 37% for males and 31% for females, i.e. a per-centage of 6 in favour of the former. The sexes taken separately and examined in age periods reveal nothing note-worthy.

As already explained in an earlier part of the paper the urine collected at 8 a.m. represented the absorption and metabolism in the fasting child, while that collected at 8 p.m. represented the absorption and metabolism of the child while

the process of digestion and absorption were active, and we might hence expect that these morning and evening urines would shew some decided difference in reducing power. In some individual cases there was indeed a marked difference, but this was constant neither in different individuals nor in the same individual from day to day, and in some we have exactly the same average during each period of 12 hours. Taking the mean of all samples examined the difference practically disappears, the per centage of evening reductions representing the process of digestion being 51 while 49 represents that of the morning or fasting urines.

The Reducing Action of the Urine in Scarlet Fever

(Appendix, Table III)

The reducing action of the urine in Scarlet Fever was investigated in 40 patients, but as five of these cases were incomplete, the remarks which follow will apply to the remainder, 35 in number. The samples were collected at eight in the morning and at the same hour in the evening, so that the latter represents the urine of the period of digestion. In all 1,139 samples were examined, divided in nearly equal proportions between the two periods just referred to. Of this number 726 gave no evidence of reducing power, while in 413 samples the evidence of reducing power was unequivocal. This gives a proportion of 36.2%. On analysing the number of urines which manifested reducing power, we find that of the total only 14 or 3.4% gave an "immediate" reaction, the other reductions being "remote." In other words, of the

whole number of samples examined only 1.2% gave "immediate" reductions, in this, as was the case in chicken-pox, contrasting strongly with whooping-cough in which the "immediate" reductions formed 32% of the total samples examined. These "immediate" reductions occurred in eight of the cases, leaving 26 in which every reduction was "remote." In one case no single sample gave evidence of reducing power, and in a second case every sample reduced the test solution with facility. Thus the reducing power ranged from 0-100%, and between these extremes every degree of reducing power was represented. So far as could be judged the stage of the illness had absolutely no influence on the frequency or extent of the reductions. The degree of the reducing power seemed to vary greatly in different individuals as was also the case with the frequency of reduction, both of these being best seen among the younger children, though here individual indiosyncracy seemed to play an important part, for in certain

of the children the reductions were constantly much more powerful than in others.

The period of the day would seem in the case of Scarlet Fever as in other diseases to exercise quite a decided influence upon the reducing power of the urine, and this influence was again such as to produce a markedly higher reducing power among the "night" than among the "day" samples. Of the total samples 564 were collected in the morning, and 575 at night, the former including the "night" or fasting samples, and the latter those passed while digestion was active. Of the former, 218 or 38.7% manifested reducing power, while of the latter 195 or 33.9% possessed the power of throwing down suboxide. These figures show that the reducing power of the "night" or fasting urines was about 5% greater than that of the urine passed during the day. The children examined included 18 males and 17 females, and the samples tested were derived, 607 from the former and 532 from the latter. Of the samples collected from the males

219 or 34.4% possessed distinct reducing power, while of those collected from females 194 or 36.5% reduced the test solution.

The relation of the reducing power to age among children suffering from Scarlet Fever emphasizes the points brought out by the examination of this question in the case of varicella, as will be seen from the accompanying table in which the ages are arranged in periods of one year. The youngest child whose urine was examined was two years of age and the oldest twelve.

Age	Reductions per cent.
0-1 year	No cases
1-2 years	No cases
2-3 "	69.7
3-4 "	53.6
4-5 "	47.0
5-6 "	39.0
6-7 "	42.0
7-8 "	23.0
8-9 "	18.0
9-10 "	20.9
10- "	7.7

There were no sucklings among the cases observed in this disease, but the gradual fall in the

reducing power of the urine with increasing age is very striking. This feature, it will be recollected, was not strikingly marked among the recorded cases of whooping-cough.

The Reducing Power of the Urine in Measles.

A detailed analysis of all the diseases examined, on the lines followed in varicella and Scarlet Fever would occupy too much space and extend this thesis beyond reasonable limits, I shall therefore synopsize my results and give as concisely as possible the conclusions to which I have come, contrasting in tabular form the number of cases examined in each disease, and the reducing power of the urines both "immediate," and "remote."

The urine was examined in 93 cases of measles, but owing to the fact that the experiments were carried out early in the course of my investiga-

tions, in a considerable number a record was kept of the "immediate" reductions only. In those examined later, both "immediate" and "remote" reductions were noted. The samples were collected at the same hours as in the diseases already recorded, and the circumstances, surroundings, and food of the patients were practically the same in every instance.

The "immediate" reductions which as already stated were recorded in all the cases, amounted to 1.45% of the samples examined, the number of which exceeded 5,000, while the "remote" reductions which were recorded in only a small proportion of the cases amounted to no less than 57.5%. This latter proportion, I feel confident, is much too high, and further observations will no doubt considerably reduce it. As in the diseases already discussed the "night" or fasting urine possessed greater reducing power than the "day" urines, the proportions being 67% reductions among the "night" as compared with 53% among the day urines.

In regard to sex and age the same points were noticeable as in the other diseases. Sex apparently had little influence on the reducing power, while the same marked reducing action among the younger as compared with the older patients was evident as in chicken-pox, and Scarlet Fever.

Reducing Power of the Urine in Diphtheria.

The urine was examined in five cases of this disease - 2 males and 3 females with a total of 168 samples, equally divided between the periods of day and night. Of these 105 gave no evidence of reducing power while 63 reduced Fehling's solution more or less actively. This gives the large proportion of 60% ofurines showing reducing power. Of these reductions 8 were "immediate" equal to 4.7%. Individual indiosyncracy apparently was responsible for many of these reductions, seeing

that 53 out of the total 63 reductions occurred in two of the patients the balance being divided between the other 3 cases. This is strikingly seen in the fact that all the "immediate" reductions, 8 in number occurred in the same individual, the proportion of "immediate" reductions to the samples examined was 4.5%. Of the two cases referred to one was a male, the other a female; in the former 90% of the samples and in the latter 72% showed reducing power. The night and day reductions were equal in number being 43.5% of the total samples during each period of 12 hours.

We have now completed our analysis of the observations carried out upon the urine of children suffering from zymotic diseases, and it now remains to discuss the reducing power of the urine in children suffering from non-infectious diseases. As already remarked the investigations into this class was necessarily less complete and continuous than in the infectious diseases, owing to the absence of segregation. It would be quite im-

possible to give complete details of all the cases examined in this place, and I shall content myself with stating in a tabular form these points which bear most directly upon the facts brought out in whooping-cough, which after all, is the main object of the thesis. The annexed table gives all the details referred to and is arranged, the first part in the order of the "immediate" reductions, while the latter part containing those cases in which the urine showed no "immediate" reducing power is arranged in the order of the "remote" productions.

Table shewing the Reducing Power of the Urine in different diseases with "immediate" and "remote" reactions.

Name of Disease	No. of Cases	Imm. Red.	Rem. Red.	Total Red.	Remarks
Whooping-cough	66	32%	18%	50%	
Gen. Convulsions	3	14.3%	0%	14.3%	
Epilepsy	5	10%	0%	10%	
Pleurisy	15	5.2%	13.8%	19%	
Enteric Fev.	17	5%	40%	45%	
Dis. of Spinal Cord	13	5%	28%	33%	
Tub. Peritonitis	9	4.8%	33.2%	38%	
Psoriasis	10	4.4%	31.1%	35.5%	
Diphtheria	5	4.7%	55.3%	60%	
Anaemia	151	3.9%	25.3%	29.2%	
Gastric Catarrh	63	3.2%	27.1%	30.3%	
Tonsilitis	15	3. %	20%	23%	
Varicella	55	3.9%	30.1%	34%	
Bronchial Catarrh	134	2.3%	33.7%	36%	
Tub. of bone and glands	95	2.2%	21.8%	24%	
Small-pox	3	2.2%	43.8%	46%	One case, Red. 100%
Intestinal Catarrh	126	2%	28.9%	30.9%	

Name of Disease	No. of Cases	Imm. Red.	Rem. Red.	Total Red.	Remarks
Bronchitis	100	2%	28%	30%	
Rickets	82	1.6%	26.4%	28%	
Measles	93	1.45%	55.5%	57.5%	
Scarlet Fever	35	1.2%	35%	36.2%	
Chronic Abscess	39	1.2%	28.8%	30%	
Healthy Children	364	1. %	23.5%	24.5%	
Eczema	149	0.7%	35.7%	36.4%	
Phthisis	34	0.5%	38.1%	38.6%	One case gave Red. 60%.
Chorea	36	0.5%	29.5%	30%	
Burns	2	0. %	100%	100%	
Cardic	16	0%	63.2%	63.2%	One case, Red. 80%
Scabies	2	0%	55.%	55%	
Pseudo-hyper Par	1	0%	54 %	54%	
Pemphigus	5	0%	53 %	53%	
Cirrhos. of liver	1	0%	50%	50%	
Pneumonia (Croup)	4	0%	50%	50%	
Tabes Mesent.	6	0%	50%	50%	
Cerebral tum.	1	0%	40%	40%	
Laryngitis	3	0%	33%	33%	
Syphilis	2	0%	33%	33%	
Mumps	10	0%	30%	30%	
Neuralgia	7	0%	29.2%	29.2%	
Tubercular Meningitis	2	0%	27.2%	27.2%	

Name of Disease	No. of Cases	Imm. Red.	Rem. Red.	Total Red.	Remarks
Strophulus	2	0%	25%	25%	
Nephritis	10	0%	24.4%	24.4%	
Herpes 3	3	0%	24%	24%	
Rheumatism	15	0%	10%	10%	
Broncho-pneumonia	10	0%	5.3%	5.3%	

A study of this table reveals several points of great interest. Confining our attention in the meantime to the figures indicating the proportions of "immediate" reduction, we see that whooping-cough which is essentially a convulsive disease heads the list with 32%, and is followed, though at a considerable distance by two other conditions both characterised by convulsive seizures, viz., general convulsions, no doubt resulting from various causes, and epilepsy. In all of these diseases the intensity of the reducing power is very marked though in both, convulsions and epilepsy, the <u>frequency</u> is not great. Chronic diseases of the nervous system unassociated with convulsions likewise show a tolerably high intensity of reducing power as well as a very considerable frequ-

ency.

Those diseases in which irritation of the skin and mucous membranes is a prominent feature possess a marked intensity, and in some cases as in diphtheria and tubercular peritonitis, a high frequency of reducing power.

Another point which is worthy of attention especially in view of the suggested explanation that the reducing power of the urine in whooping-cough is due to the cerebral congestion caused by the cough itself, and this is the fact that the diseases associated with cough such as bronchitis, bronchial catarrh, croupous pneumonia, and bronchopneumonia, do not manifest a reducing power upon Fehling's solution above the average, and in bronchopneumonia shows a "remote" reducing power of only 5.3%.

It would be difficult to say how much of the reducing power of the urine was due to the diseases from which the children suffered, but the fact that the great majority of the diseases investigated

showed reducing power in about 30% of the samples examined would suggest that this per centage indicates about the average of reducing power altogether independant of diseased conditions; but I would again call attention to the important part played by the patient's idiocyncrasy. This last point is referred to in several instances as will be seen by turning to the preceding table.

The table furnishes an answer to the question whether the urine of presumably healthy children possesses a distinct reducing power on Fehling's solution. Altogether the urine was examined in 364 children, all of whom failed on careful examination to give any indication of general disease. Children with naevi, slight ring-worm, and other slight local affections were regarded as healthy for the purpose of this investigation. In the cases examined exactly 1% of the urines gave "immediate" and 24.5% "remote" reductions. We are therefore in a position to assert with confidence that not only does the urine in diseased conditions possess reducing power, but that the urine of

healthy children likewise manifests such power in a very marked degree. It would thus seem probable that in the urine of children there is present in variable amount, but more or less constantly some substance which possesses the power of precipitating cuprous oxide from alkaline solutions of copper salts.

Cause of the Reducing Power of the Urine in Childhood.

We have now reached the last stage of our inquiry, and our object will now be to find an answer to our fifth question, viz., "What is the nature of the "substance or substances which confers upon the "urine of childhood its reducing power in whooping-"cough and other conditions?"

While a number of chemical substances formed within the animal body either as a result of metabolism or secretion, or obsorbed directly from substances taken into the alimentary canal as food, are found in the urine, some of these are so rarely present under any circumstances in amount sufficient to reduce Fehling's solution, that they may be altogether excluded from consideration; we shall therefore confine ourselves to a discussion of the properties of six substances found more commonly in

the urine in quantities sufficient to influence Fehling's test. These substances are, 1st. Glycuronic Acid, 2nd. Indican, 3rd. Uric Acid, 4th. Kreatin, 5th. Kreatinin, and 6th. Sugar - including under this last term all the various forms of sugar which may occasionally find their way into the urine, and there act as reducing agents upon certain metallic salts, and which are capable of undergoing the process of fermentation either directly or indirectly.

Glycuronic Acid.

This substance is closely related to dextrose forming, when oxidised, saccharic acid. It reduces Fehling's solution quite as powerfully as glucose, the reduction being accompanied by the precipitation of cuprous oxide. It will thus be seen that in glycuronic acid we have a substance which may give rise to serious fallacy when experimenting upon Fehling's solution. In point of

fact, however, this acid is but rarely found in human urine, and when present is the result of tolerably well known conditions, such as the administration of Chloral Hydrate and a few other drugs.

Indican.

This body is frequently quoted as likely to give rise to fallacy by causing a reduction of Fehling's solution, but in point of fact urinary indican probably never, under any circumstances, reduces metallic salts with the separation of a precipitate. This error has probably arisen from the fact that two substances differing altogether chemically, are referred to under this common name. The most commonly known of these exists in woad and yields on decomposition by dilute acids two substances, namely, indigo-blue, and indiglucin. The latter of these substances reduces alkaline solutions both of copper and silver salts, but it is

never found in urine.

The true urinary indican is probably derived from indol formed within the intestin, and appears in the urine as an ethereal compound of sulphuric acid with indoxyl. The potassium salt of indoxyl sulphuric acid is found in the urine in varying amount, and may be readily detected by oxidation which results in the formation of indigo-blue. Although both urinary and plant indican give rise to a similar reaction, yet as has just been stated they are essentially different chemically and only the latter reduces Fehling's solution. This fact I have had occasion to observe very frequently in the course of my observations upon indican in urine; when urines which contained a large per cent. of indican as gauged by the usual test, have invariably failed to manifest any reducing action upon Fehling's solution.

Uric Acid.

Free uric acid and its salts are generally classed together, as substances possessing a reducing power upon Fehling's solution. The existence of such a reducing power cannot be denied, but it is so feeble that in the majority of experiments upon Fehling's solution its existence may be ignored. In some experiments conducted with the object of studying this point it was found that urines containing a copious precipitate of mixed urates when treated with an excess of Fehling's solution, gave rise to a dirty brownish precipitate which could scarcely be mistaken under any circumstances for the precipitate caused by glucose. The same is true of free uric acid except when it is dissolved in large amount in Fehling's solution. Another point to which it may be worth while to call attention is this, viz., that a large proportion of urine containing uric acid or urates also contain a decid-

ed amount of sugar, and under such circumstances will naturally reduce Fehling's solution with the precipitation of cuprous oxide. Such urines ferment, and that occasionally very freely.

Turning now to kreatin and kreatinin, it will be most convenient to consider them together, remembering that it is still questionable whether kreatin itself is ever found in urine. These substances are very closely related both in their chemical constitution and in their action upon Fehling's solution; and it must also be remembered that in all probability neither, as excreted in the urine, is derived from tissue change but both are absorbed from the alimentary canal, and excreted unchanged in the urine, their source being muscular tissue taken as food. The following short table is intended to shew the effect upon Fehling's test of solutions in varying strength of these substances. The amount of Fehling's solution was kept in considerable excess in each ex-

periment. The solutions were made in water and in urine which had been carefully tested beforehand to determine the absence of reducing power.

Kreatinin

Sol. per cent.	Solut. in Water	Solut. in Urine
10 (Warm)	Immediate Reduction but without precipitation of suboxide of copper. The mixture becomes greenish yellow.	Immediate Reduction but no precipitate of suboxide of copper. Mixture brownish in colour.
5 (Cold)	Immediate Reduction but no precipitation of suboxide of copper. Mixture turns yellowish green.	Immediate Reduction but no suboxide precipitated. Colour of mixture greenish brown.
2.5	Reduction less marked; no precipitation of suboxide of copper. Mixture becomes greenish blue.	Slow reduction but no suboxide of copper precipitated. Mixture greenish blue in colour.
1.25	No reduction: blue colour unchanged.	No reduction: blue colour unchanged.

Kreatin

Sol. per cent.	Solut. in Water	Solut. in Urine
Hot saturated solution	Immediate reduction but no suboxide of copper precipitated. The mixture becomes green in colour.	Immediate reduction. No precipitate of suboxide of copper. Colour green with brown tints.
5 (Hot)	Immediate reduction but no suboxide precipitated. Mixture greenish blue in colour.	Immediate reduction. No precipitate of suboxide. Colour of mixture greenish blue.
2. 5 (Hot)	Reduction slow: no precipitate of suboxide. Colour of mixture greenish blue.	Slight reduction: no suboxide precipitated. Colour of mixture blue tinged with green.
1.25 Saturated cold solution	No reduction. No change in blue colour.	No reduction. The colour unchanged.

An examination of the solutions after 24 hours shewed they had undergone no further change in the interval, the solutions of the reagents both in water and urine continuing perfectly transparent. The reducing power of kreatinin would seem to be greater than that of kreatin, but in neither case was any reduction whatever got with a 1.25% solution containing an amount of these substances greatly in excess of anything ever found in urine. The entire absence of precipitate with both reagents should be carefully kept in view.

A perusal of the facts here set forth will make evident two very important points:- 1st. That only solutions of great strength have any reducing action upon the test solution; and 2nd. that this reduction is <u>not</u> attended by any separation of cuprous oxide, the reduced oxide being kept in solution by both reducing agents. As all our observations depend upon the <u>separation</u> and precipitation of the suboxide it must be obvious that

neither kreatin nor kreatinin can be legitimately considered as responsible for the reducing power of the urine in childhood, at least so far as the observations which have just been recorded teach. Further, as already explained, Kreatin and kreatinin when present in the urine are not the result of chemical changes occurring in the person from whom the urine is derived, but are absorbed unchanged from animal food taken into the stomach to the amount of which they seem to be in direct proportion. Now by far the greater number of the patients whose urines form the basis of this paper were children taking in most cases a minimum of animal food, while from some during the period of observation, animal food was entirely withheld, their diet consisting mainly of farinaceous substances with milk. Many of the children, as already stated, were sucklings and in these the reducing power of the urine was more highly developed than in the others. It will be obvious, therefore, that this single consideration regarding the character of the diet

forces us to conclude that neither kreatin nor kreatinin is responsible for the reducing power of the urine in childhood.

Soon after the commencement of these investigations I found accidentally that urines which originally possessed the power of reducing Fehling's solution lost this on standing exposed to the air. After satisfying myself by a considerable number of experiments of the correctness of my observation, I instituted a series of 48 experiments, detailed in the accompanying table, with the object of studying the details of this process. The urines referred to were examined every 12 hours, 6 C.C. of Fehling's solution and 4 C.C. of urine being accurately measured in each experiment. The reaction was taken with litmus paper in every instance.

Table shewing gradual loss of reducing power in 48 Samples of Urine on standing

C = Considerable, D = Distinct, T = Trace, M.T. = Minute Trace, A = Acid, A- = diminished acidity

Sample I.			Sample II.			Sample III.		
Hour	Red.	React.	Hour	Red.	React.	Hour	Red.	React.
0	T	A	0	T	A	0	D	A
12	T	A	12	T	A	12	D	A
24	T	A	24	T	A	24	D	A
36	T	A	36	T	A	36	D	A
48	T	A	48	none	A	48	T	A
60	none	A	60	none	A	60	T	A
72	none	A	72	none	A	72	T	A
84	none	Alk.				84	T	A
						96	T	A
						108	T	A
						120	none	A
						132	none	A
						144	none	A-

Sample IV.			Sample V.			Sample VI.			Sample VII			Sample VIII.		
Hour	Red.	React.	Hour	Red.	React.	Hour	Red.	React.	Hour	Red.	React.	Hour	Red.	React.
0	D	A	0	MT	A	0	D	A	0	C	A	0	C	A
12	D	A	12	MT	A	12	D	A	12	C	A	12	C	A
24	D	A	24	MT	A	24	T	A	24	D	A	24	D	A
36	D	A	36	none	A	36	T	A	36	D	A	36	D	A
48	T	A	48	none	A-	48	MT	A	48	T	A	48	T	A
60	T	A				60	MT	A	60	T	A	60	T	A
72	T	A				72	MT	A	72	T	A	72	T	A
84	none	A				84	MT	A	84	T	A	84	T	A
96	none	A				96	none	A-	96	MT	A	96	T	A
108	none	A				108	none	A-	108	MT	A	108	T	A
						120	none	A-	120	none	A-	120	none	A-
									132	none	A-	132	none	A-
												144	none	A-

Sample IX.			Sample X.			Sample XI.		
0	MT	A	0	MT	A	0	T	A
12	MT	A	12	MT	A	12	T	A
24	none	A	24	none	A	24	T	A
36	none	A-	36	MT	A	36	T	A
48	none	A-	48	MT	A	48	MT	A
60	none	A-	60	MT	A-	60	MT	A
			72	none	A-	72	MT	A
			84	none	A-	84	none	A
			96	none	A-	96	none	A
						108	none	A-

Sample XII.			Sample XIII.			Sample XIV.			Sample XV.			Sample XVI.		
0	D	A	0	T	A	0	MT	A	0	D	A	0	T	A
12	D	A	12	T	A	12	MT	A	12	D	A	12	T	A
24	D	A	24	T	A	24	MT	A	24	T	A	24	T	A
36	D	A	36	T	A	36	none	A	36	T	A	36	none	A
48	none	A	48	T	A	48	none	A	48	T	A	48	none	A
60	none	A	60	none	A-				60	none	A	60	none	A
72	none	A	72	none	A-				72	none	A			

Sample XVII.			Sample XVIII.			Sample XIX.		
0	T	A	0	T	A	0	T	A
12	T	A	12	T	A	12	T	A
24	T	A-	24	T	A	24	T	A
36	T	A-	36	none	A	36	T	A
48	none	A-	48	none	A	48	none	A-
60	none	A-				60	none	A-

Sample XX.			Sample XXI.			Sample XXII.			Sample XXIII.			Sample XXIV.		
0	C	A	0	D	A	0	T	A	0	D	A	0	D	A
12	C	A	12	D	A	12	T	A	12	D	A	12	D	A
24	D	A	24	T	A	24	T	A	24	T	A	24	D	A
36	D	A	36	T	A	36	MT	A	36	T	A	36	D	A
48	T	A	48	T	A	48	MT	A	48	T	A	48	D	A
60	T	A	60	T	A	60	none	A	60	T	A	60	T	A
72	none	A-	72	none	A-	72	none	A	72	MT	A	72	none	A-
84	none	A-	84	none	A-	84	none	A	84	MT	A	84	none	A-
96	none	A-							96	none	A	96	none	A-
108	none	A-							108	none	A			

Sample XXV.			Sample XXVI.			Sample XXVII.		
0	D	A	0	D	A	0	D	A
12	D	A	12	D	A	12	D	A
24	T	A	24	D	A	24	T	A
36	none	A	36	T	A	36	T	A
48	none	A	48	none	A	48	T	A
60	none	A-	60	none	A-	60	MT	A
			72	none	A-	72	MT	A
			84	none	A-	84	none	A-
						96	none	A-
						108	none	A-

Sample XXVIII.			Sample XXIX.			Sample XXX.			Sample XXXI.			Sample XXXII.		
0	C	A	0	T	A	0	MT	A	0	D	A	0	D	A
12	C	A	12	T	A	12	MT	A	12	D	A	12	D	A
24	D	A	24	T	A	24	MT	A	24	T	A	24	D	A
36	D	A	36	MT	A	36	MT	A	36	T	A	36	T	A
48	T	A	48	none	A	48	MT	A	48	MT	A	48	T	A
60	T	A	60	none	A	60	none	A	60	MT	A	60	MT	A
72	MT	A				72	none	A-	72	none	A-	72	none	A
84	none	A-				84	none	A-	84	none	Alk.	84	none	A-
96	none	A-							96	none	Alk.	96	none	A-
108	none	A-												

Sample XXXIII.			Sample XXXIV.			Sample XXXV.		
0	D	A	0	D	A	0	T	A
12	D	A	12	D	A	12	T	A
24	D	A	24	T	A	24	T	A
36	D	A	36	T	A	36	T	A
48	T	A	48	T	A	48	MT	A
60	T	A	60	T	A	60	MT	A
72	T	A	72	T	A	72	none	A
84	T	A	84	T	A	84	none	A
96	T	A	96	T	A	96	none	Alk.
108	none	A-	108	MT	A			
120	none	Alk.	120	MT	A			
			132	MT	A-			
			144	MT	A-			
			156	none	Alk.			
			168	none	Alk.			

Sample XXXVI.			Sample XXXVII.			Sample XXXVIII.			Sample XXXIX.			Sample XL.		
0	T	A	0	D	A	0	T	A	0	D	A	0	T	A
12	T	A	12	D	A	12	T	A	12	D	A	12	T	A
24	T	A	24	D	A	24	T	A	24	D	A	24	MT	A
36	T	A	36	D	A	36	T	A	36	D	A	36	MT	A
48	MT	A-	48	D	A	48	MT	A	48	D	A	48	MT	A
60	MT	A-	60	D	A	60	MT	A	60	D	A	60	MT	A
72	none	A-	72	T	A	72	MT	A	72	D	A	72	MT	A
84	none	A-	84	T	A-	84	none	A-	84	D	A	84	none	A-
96	none	A-	96	MT	A	96	none	A-	96	T	A	96	none	A-
			108	MT	A	108	none	A-	108	T	A			
			120	MT	A	120	none	A-	120	MT	A-			
			132	none	A-				132	MT	A-			
			144	none	A-				144	MT	A-			
			156	none	A-				156	MT	A-			
									168	MT	A-			
									180	MT	A-			
									192	none	A-			
									204	none	A-			

Sample XLI.			Sample XLII.			Sample XLIII.		
0	T	A	0	D	A	0	D	A
12	T	A	12	D	A	12	D	A
24	T	A	24	D	A	24	D	A
36	T	A	36	D	A	36	D	A
48	T	A	48	D	A	48	T	A
60	MT	A	60	T	A	60	T	A
72	MT	A	72	T	A	72	T	A
84	none	A	84	none	A	84	T	A
96	none	Alk.	96	none	A-	96	MT	A
			108	none	A-	108	MT	A
						120	MT	A-
						132	MT	A-
						144	MT	A-
						156	MT	A-
						168	MT	A-
						180	MT	A-
						192	none	A-
						204	none	A-
						216	none	A-

Sample XLIV.			Sample XLV.			Sample SXLVI.			Sample XLVII.			Sample XLVIII		
0	C	A	0	C	A	0	D	A	0	C	A	0	C	A
12	C	A	12	C	A	12	D	A	12	C	A	12	C	A
24	C	A	24	C	A	24	D	A	24	C	A	24	D	A
36	D	A	36	C	A	36	D	A	36	C	A	36	D	A
48	D	A	48	D	A	48	T	A	48	D	A	48	D	A
60	D	A	60	D	A	60	T	A	60	D	A	60	T	A
72	T	A	72	T	A	72	MT	A	72	D	A	72	T	A
84	T	A	84	T	A	84	MT	A	84	D	A	84	T	A
96	MT	A	96	none	A	96	none	A	96	D	A	96	none	A-
108	MT	A	108	none	A-	108	none	A-	108	D	A	108	none	A-
120	MT	A	120	none	A-	120	none	A-	120	D	A			
132	none	A-				132	none	A-	132	T	A			
144	none	A-							144	T	A			
156	none	A-							156	T	A-			
									168	none	A-			
									180	none	A-			

Analysis of this detailed statement shows that- 1st. The reducing power of the urine is lost gradually so far at least as we are able to judge by the gradually diminishing amount of cuprous oxide precipitated. 2nd. The period occupied by this gradual loss of reducing power varied greatly, ranging from 24 to 180 hours. This variation, so far as could be judged, seemed to depend in part upon the intensity of the reducing power originally possessed by the urine; those samples which were most actively reductive taking longest, while those samples which presented only slight power of reduction lost this very quickly. This, however, was not always the case and the rapidity with which the reducing power disappeared seemed to depend to a certain extent upon the temperature of the laboratory, being lost more rapidly in hot than in colder weather. That this conjecture is probably correct, was supported by the fact that the reducing power could in most cases be destroyed with great rapidity by placing the urine in a water oven at a temperature of 30° to 33°C. Under

these circumstances the reducing power was lost in most of the experiments within 48 hours.

3rd. It will also be observed that all the samples possessed originally a decided acid reaction, which was maintained in every instance until the reducing power of the urine was lost. This continued acidity was not stationary but shewed a distinct increase till shortly before the reducing power of the urine disappeared, when it gradually became less and was finally lost, giving way to alkalinity soon after the loss of its power of reducing the test solution. This gradual increase in acidity could be easily demonstrated by reducing the acidity of the urine nearly to the point of neutralisation by means of a dilute solution of sodium carbonate, when as the hours passed a steady and gradual return of the higher degree of acidity could easily be determined by the varying colour of the litmus paper. Though ammoniacal change of a marked character was invariably absent so long as the urine retained its reducing power, yet the urine underwent putrefactive change and swarmed with bacteria long before,

at least in some instances, it ceased to manifest its power of reducing Fehling's solution.

These urines when examined microscopically invariably discovered the presence of yeast spores. As stated already, the reducing power of the urine was more rapidly lost when exposed in a water oven for 24 to 48 hours, than when left at the ordinary temperature of the atmosphere, but even this loss of power could be greatly accelerated by the addition of a few crumbs of yeast which, so far as I have been able to ascertain, invariably destroys the reducing power in from 12 to 36 hours. With the object of confirming these observations a number of samples of urine possessing distinct reducing power were sterilised by boiling, and on testing these after periods varying from one week to three months they were all found to have retained their reducing power.

These observations demonstrate that the property possessed by so many of these urines of

reducing Fehling's solution depends upon the presence of some substance which undergoes change of some kind resulting in a destruction of its reducing properties, and that this change is accompanied by the formation either of free acids or of acid salts and the growth of torula spores. The only substance found in urine within my knowledge capable of maiifesting these various phenomena is sugar. To confirm this impression about 500 of the samples of urine manifesting reducing power were fermented with yeast, all the precautions which have been already detailed being carefully observed. The result was that in every case without exception a certain amount of gas was obtained varying from 3 or 4 up to 100 C.C., and in rare instances even more. In many of the experiments the gas was obtained only after boiling, but the number in which a considerable amount was evolved and was readily appreciated without the necessity of "boiling off" was considerable. The gas evolved on testing with lime-water was

always found to be carbonic acid. A great increase in acidity was manifested by these urines after completion of fermentation with yeast, and was very striking when compared with urines not manifesting reducing power, when these were subjected to fermentation with yeast from which adventitious sugar had been completely removed. These last urines evolvedno gas.

The experiments here recorded seem to leave little doubt as to the nature of the reducing substance found in the urines examined. Indican, Kreatin, and Kreatinin cannot be regarded as the cause of the reducing power of the urine in childhood, because the first of these (Indoxl sulphuric acid) does not reduce Fehling's solution, while the others though acting as reducing agents do not cause a separation and precipitation of cuprous oxide. Glycuronic acid and Uric acid with their salts both reduce Fehling's solution. The former though a powerful reducing agent is found in urine under exceptional conditions only; the latter pos-

sesses but slight reducing power and probably except when employed experimentally in the laboratory never give rise to complications with Fehling's test. Neither Glycuronic nor uric acid undergo fermentation with yeast and neither of them loses its power of reducing Fehling's solution on standing exposed to the air.

The last question of the series formulated at the commencement of this paper alone remains to be discussed, and though the answer must, in the meantime, be a purely speculative one, yet the observations recorded up to this point, may be made to throw a certain amount of light upon the presumptive nature of whooping-cough. In a large number of the cases observed both healthy and diseased, the reducing power of the urine would seem to depend partly on the character of the food and partly on the age of the patient, though undoubtedly in some of the children that somewhat vague attribute generally known as idiosyncracy plays an important part. The influence

of diet may be strikingly seen in the case of sucklings whose urine always manifests a very high reducing power, a power which, however, is much reduced when the child is taken from the breast and fed on cow's milk or other suitable form of food. Many examples of indiosyncracy were met with. The urine of certain of the children who lived under precisely the same condition as their companions in regard to hygienic surroundings and diet, often presented an unusually high degree and constancy of reduction. In some this condition was so marked that an examination of the urine without reference to the general condition of the patient might easily have given rise to a diagnosis of slight diabetes. The influence of age on the reducing power of the urine has been more than once referred to, and this influence would seem to result in a more frequent and more abundant presence of glucose in the urine during the earlier than during the

later years of childhood. This would point in the direction of a gradual but steady change in the processes of digestion, absorption, or metabolism.

While all of these circumstances are no doubt operative in whooping-cough as in other diseased conditions and in health, yet there would appear to be something more in this disease to account for the great increase in the number of "immediate" reactions or in other words, the much greater amount of glucose present in the urine in this as compared with other diseases. It has been already shown that the great amount of glucose in the urine of whooping-cough cannot be attributed to congestion of the nerve centres, or to the poisoning of these by carbonate acid, and we must search for some other cause to explain the phenomenon. This conclusion is further supported by the fact that in other diseases associated with defective oxidation of the blood, e.g. pulmonary

and cardiac affections, the reducing power of the urine is not increased beyond what may be regarded as normal to childhood.

The close anatomical relation existing between the respiratory and glycogenic centres in the medulla would point out the direction in which our inquiries should be carried out. In this connection there are two explanations either of which would account both for the peculiar and more obvious characters of whooping-cough as well as for the presence of Glucosuria. The first of these may be called the "reflex" theory and the second the "direct". The profound influence exercised by whooping-cough upon the nervous system and the aggravation of the attacks by peripheral stimuli, would suggest the existence of a hyperaesthetic condition of the medulla in the neighbourhood of the respiratory centre or else a hyperaesthetic condition of the nerve terminals in the respiratory tract from the naso-pharyns downwards. The

latter theory would readily enough account for all the phenomena of whooping-cough, and is supported by the well known fact that inflammatory diseases of the respiratory apparatus occuring as complications in the course of an attack of whooping-cough may arrest the characteristic manifestations of the disease. It is likewise supported by the fact that a slight catarrh of the respiratory passages may after many months give rise to a recurrence of the characteristic features of the disease, though under such circumstances, that attack does not appear to be infectious. The infectivity of the nasal and bronchial mucus taken in association with the practical absence of fever in uncomplicated whooping-cough would suggest that possibly a micro-organism having a purely local habitat, and unassociated with the absorption of chemical products may be the exciting cause of whooping-cough, the glucosuria being merely one of the less obvious symptoms. The possibility of producing

temporary glycosuria in a reflex manner by irritation of the alimentary canal lends support to this view.

The evidence in favour of the "direct" theory is much less conclusive, but it may be suggested that a micro-organism having its habitat in the respiratory passages may give rise to products which on absorption act more immediately upon the medulla, leaving that portion of the central nervous system for many months in a hyperaesthetic condition. This theory would seem to be supported to some extent by the fact that in very severe cases of the disease the hyperaesthesia of the medulla may, as it were, overflow its usual limits and extending to other parts of the brain and to the spinal cord give rise to extensive convulsions. In my opinion the "reflex" theory is the more probable.

Conclusions.

An analysis of the facts brought out experimentally in the course of the observations which have been recorded, points in the direction of the following conclusions:-

I A large proportion of the urine of children suffering from whooping-cough possesses the power of reducing Fehling's solution.

II This reducing power is present in all the phases of the disease, but is more marked both in regard to its intensity and frequency in the spasmodic than in the other stages.

III This power of reducing alkaline solutions of copper salts is not peculiar to whooping-cough, and is possessed in varying degree by most other diseases of childhood: but it is much greater in intensity in whooping-cough than in any other of the diseases investigated. The urine in every case of whooping-cough examined possessed at times a high reducing power, though the frequency with which this power shewed itself varied within very wide limits.

IV The urine of presumably healthy children also possesses the power (at times) of reducing copper salts, but the frequency of reduction is much less than in whooping-cough.

V The most important point of difference between the reducing power of the urine in whooping-cough and that derived from children suffering from diseases other than whooping-cough and from healthy children, lies in the greater intensity of the reducing power of the urine in the first of these, seeing that 32% of whooping-cough urines manifest reducing power such as would be possessed by a .25% solution of glucose.

Vl The reducing power of the urine in whooping-cough is manifested with greater certainty, and with less reference to age, than either in health or in diseases other than whooping-cough.

Vll From the fact that the urine of whooping-cough manifests reducing power in all stages of the disease and in attacks not associated with "whoop," also from the fact that the "whoop" has little influence except in so far as it measures the severity of the affection, it is clear that the reducing power of the urine is due to the pathological changes which give rise to the various symptoms constituting the disease, and is not directly caused by the passive congestion of the nerve centres, incident more especially to the spasmodic stage. This conclusion is further borne out by the observation that the urine in diseases associated with marked cough such as bronchitis does not present a reducing power strikingly beyond the average.

Vlll The reducing power possessed by the urine of whooping-cough is probably invariably due to the presence of glucose.

IX In all probability the presence of sugar in the urine of childhood is the result of a variety of conditions, such as diet, etc., but in whooping-cough the evidence points in the direction of a high degree of peripheral irritation throughout the whole length of the air passages presumably due to changes in the mucous membrane and its nerve terminals of microbic origin, which is possibly associated with a highly excitable respiratory centre, the reflex stimulation of which may at times result in an overflow of nerve energy capable of exciting the neighbouring glycogenic centre. This view is supported by the great excess of reducing power possessed by those diseases characterised by extensive irritation either of the skin, or mucous membranes.

Literature.

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(5) Pollak: "Beiträge zur Kenntniss des Harns" etc., Jahrbuch für Kinderheilkunde, Elfter Jahrgang, Heft I, p 27.

(6) Harley G: "On Origin and Destruction of "Sugar," Brit. and For. Med. Chir. Rev. 1857, Vol. XX.

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APPENDIX TABLE II. Extended Details of Observations on the Reducing power of the Urine in Chicken-Pox

A - Abundant C - Considerable D - Distinct T = Trace, M.T. = Minute Trace, "Immediate" and "Remote" Reactions.

No.	Age	Sex	Day	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	13 6/12	M																								
2	4	F																	D							
3	1 10/12	M				TT	D	D	D									D	T							
4	5	F																								
5	4	M				T	T						T	T	T			TT		TT						
6	9/12	M			TD		D	T	TMT	TT	T	T	TMT		T	MT	MT	T	D	T						
7	6	F		T	D	DT	T					T									MT	T				
8	4	M												T							T	MT				T
9	2 6/12	M									T			C				MT		T	T	MT		TT	D	T
10	3 8/12	M		MT	MT			T			MT		MT	T			T	T	MT	T	C	TT	MT	T		
11	2 8/12	F					T		T				T										D	TD	T	T
12	2 10/12	F		T																						
13	5	M		MT																	T					
14	3 9/12	F		MT		TT		DT	TD	TT	MT	CMT	MT		MT	T	C	D	MT	C	MT	MT			TT	T
15	1	F				TT		TT	TT		T		MT	T	MT		MT	T	T	MT		MT				T
16	2 6/12	F		T	T	T	D		T		T		MT	T	T	T	TD			MT				T	T	D
17	3	M									T															
18	12	F									T	T		MT	T	MT				T	MT T	TT				
19	5	F			TT	TT	TT	T						T												
20	4 9/12	M																			MT	MT T	MT T	T		
21	1 9/12	M																	MT			MT MT	T	MT		
22	6	F												T							MT	MT	MT	TT		
23	4	M								T											T					D
24	5	F				C	T	MT MT			MT MT						TT				D					
25	2 6/12	M		T		MT	MT	MT	DT	C	TT	TT	C	C	DT	DT	T			D	DD	T		DT	T	T
26	7	M			D										D										CT	CC
27	2 6/12	F						D		MT	D MT	CC	C	T		C	T		T	DT				TD	TD	
28	7	M							T	C	T MT				T	TC		MT	D	T					T	
29	10	F		T	T	C		MT			T	T	C	T MT												D
30	7	M			T	CT		MT			T	D	C	C		MT T										T
31	4	F								T	TD	CD	TT	TD	T	T	T	T	T		T	T MT	D MT	C	D MT	T
32	2	M							TT	TT	DC	TT	TT	T				T		TT	MT	T		CC	CT	T
33	6 6/12	M						D	TT	MT		T		T	T			T	CD	CD	MT T		T			D
34	12	M					MT		T	TT	D	T			T	DD	TD			T		MT	C	T		
35	2 6/12	M					TT	T	MT	TC	DT	DC	TT MT	DD	T	D	TT	DT	C MT	MT T	T	T			T	
36	6	F		MT	TD	TT	CC	CT	T	D	MT	MT	T		T		T		MT			TT	T			
37	2 6/12	M				DD		MT			MT	D MT		T		T	MT	TT	TT	TT	TD	D			T	DC
38	4	M					D	T				MT										MT	MT	DD	C	T
39	2 6/12	M								T						D	DT	T	T	MT T		D	C	MT		MT
40	3	M				T	TT	TT	TC	D	TD	TD	TC	C			MT			D	TD	TT	DT MT	CT		TT
41	1 6/12	F				D	DT	DT	CD	D	DC	CD	CC	TC		T MT	T		T	TD	TT	T	T	TD	T	
42	8	F					T			T	MT	MT	T	T	MT	T										
43	2	M						MT	MT								MT									TT
44	6Wks.	M				C	CC	D	DC	C T	C	D	DD	C	C	CT	TA		TD		MT T	MT MT				
45	4 6/12	F			MT	MT	T	T	T	MT	T	T							TT	T						
46	6	F								MT	MT									TT	MT T	TT	DT	TT	TT	DT
47	4	F			MT		T	MT		MT					T	T	MT T	MT MT	DT	DD	DT	DT	TD	DD	TT	MT
48	1 3/12	M			C	TD	DD	T	DC		D	TD		TD	D	DC	D	DT	MT C		T					
49	2 8/12	M			D	DC	DC	DC	CD	TD	TD	CD	TD	MT		MT T	TT	D	MT T		T	T MT	DC	CD	T MT	T
50	3	M			MT T	MT	TD	MT T	T	T	T	T	MT	T	MT T			MT	DT	TT	D MT	D	T	T	TC	AC
51	4	M			TC	CC	CC	CC	TT	MT	MT	TT	C	CC	CC	CT	TD	TT	TT	TC	CD	CC	T	DD	DT	D MT
52	6	M					D	TD	AA	CD	MT MT	DD	C							D	T	D MT	MT T	TT		D
53	4	M							DT	TC	TD	D MT	CD	CC	CD	D						C	D	T MT	TT	D
54	7	F			DD	DT	DC	DD	TC	CC	DD	MT		MT T	MT	TT	MT	TD	MT D	MT MT	C	C	T	CC	DT	TC
55	3	F							T	T	DD	C	CT	MT MT	MT										T	

No.	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	No Reduction	Reduction	Percentage of Reduction
1																											26		
2																											39	1	2.5
3																											32	7	18
4																											35		
5	TT	TT	TT	T	T	DT	MT	MT	T	MT	T	MT															36	24	40
6																											8	18	69.3
7																											30	8	21
8					MT				T	T																	6.4	7	10
9									T	MT	MT			T		T	D				T						85	15	15
10		MT		T	MT	MT	DT	T	MT		D																44	24	35.5
11	MT		MT	T				D							T	T											64	13	17
12																							MT				95	2	2.3
13				MT	T												MT			MT							90	6	6.2
14	T T	TT	MT	T	T																						21	31	59.6
15	MT	T																									33	18	35
16	MT	T																									30	18	37.5
17																											16	1	6
18					T	MT		T MT		T	T	T	T	T	T	MT											69	20	22.5
19						T								T		MT								D	T		80	14	15
20								T	T				T	T													65	10	13.4
21																											71	4	5.6
22																											66	7	9.5
23	T		MT	T	C	C		T	T	MT	DD	D															56	13	16.5
24	T			MT		T MT		MT			C	D MT	DD	T	T	T		T									62	21	25.5
25	MT	MT		TT		T			D	CC	TD	T		TT	T					MT	T						40	44	52.5
26	MT			D	D	D	C	T	T				T														55	14	18
27		TT	C																								29	20	40.8
28																											26	10	27.8
29	CT	MT	DC	T	TT MT	T		D	D	T																	41	23	36
30	DT	T	CC	DD	T	T			D	T	D																40	24	37.5
31							T																				30	22	42.3
32	D				T	D																					27	25	48
33	T																										21	17	45
34																											22	15	40
35	T	TD	T T																								13	32	71
36									T			MT	MT	T	DT	C	TC										54	29	36
37				MT		T					DT	CC	C	T													46	29	38.7
38																											35	11	24
39	DC																										35	14	28.5
40	DT	T	TT	TT	C	T	TT	DD	TD						T		T										35	44	55.5
41	T		TD	TD	T	T	TD	DT	D	T		MT		T	MT												35	46	57
42																											40	8	16
43	MT	MT	T	T MT	D	TT	TT	CD	T MT	T	T	MT MT	D	DT	T	T	TT	DT	DD	TT	D MT	MT T	D	MT D	MT T	T MT	79	46	36.8
44																											9	23	72
45						TD	T	T	D	CT	TT	TD	MT	T	MT			T									76	42	36
46	TD	C	DD	T	MT	TT	T MT						D	MT	T	DT	TD	MT	TT	D	T				TD	T	33	32	49
47		TD	MT T			MT	MT	T	T T		T	T	T	MT													31	34	52.5
48																											11	22	66.7
49	T	T MT	T	T MT	MT T	T MT	D																				8	46	85
50		TT	TC	TD	CD		TD		D	DD																	30	41	57.8
51	C	MT D	T MT	DD	TT	DD						MT	T	MT		MT T	MT T							T			38	60	60
52	D	T																									29	23	44
53	D		MT T	MT																							25	27	52
54	DA	CT				D	T	MT		T																	20	44	68.8
55																											21	11	32

APPENDIX, TABLE III.

Details of Reduction Action on Fehling's Solution of the Urine in 35 Cases of Scarlet Fever.

A = Abundant, C = Considerable, D = Distinct, T = Trace, M.T. = Minute Trace, "Immediate" Reacts marked (/): others "Remote"

No.	Age	Sex	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	No Reduction	Reduction	% Re.
1	3½	F			-	-	T	T	CAT	ATD	D.C	D.D	T.D	D	-	-	T	-	-	-	-	-	-	-	-										-	-	-	-		10	14	58.2
2	4½	F						T	-	TT	TA	AC	DC	DA	D	-	-	-	-	MT	-	-	-	-	-	-	-	-												9	13	54.5
3	6	F					T	MT	T	MT	T	TT	MT	-	-	-	-	-																						14	8	36
4	4	F						T	T	DD	DT	T	T	MT	MT	-	D	-	-																						12	11	48
5	4	M		-	MT	DC	T	-	-	TMT	T	-	D	-	T	-	-	-																						19	9	32
6	4	M		-	-	-	-	-	-	-	-	-	-	T	-	T	-	-	-	-	-																			29	2	7
7	3	M				T	-	T	-	T	DT	MT	D	-	T	-	-	-																							15	9	37
8	4	M						-	T	-	-	-	T	T	MT	1-	-	-	-	MT	T	-																		19	6	24
9	3	F		MT	TT	CT	CT	T	DT	CT	T	C	C	C	-	-	-	-																						14	16	53
10	4	F		C	T	CC	TC	CC	D	D	CC	CT	CC	T	C	C	TC	C	TC	CC	D	C	TC	CC	TC	TC	CD													-	37	100
11	3	M		CC	DC	CMT	TT	DD	T	-	-	-	-	T	DD	TT	MT	C	DC	CC	-																			8	22	73
12	6	F			-	-	-	-	-	DC	DD	TT	T	-	-	-	-	-	-	-	D	C	DD	C	T	-														28	12	30
13	5	M			CC	C	DT	CC	TD	C	D	-	C	T	-	C	CC	C	DT	CC	TD	C	D	-	-	C	MT	T												14	28	66
14	3	M							C	T	T	CC	C	T	C	DMT	-	-	T	-	-	-	C	T	T	C	CC	T	CD	MT	-	T	-	-						24	22	46
15	9	F	-	T	MT	T	T	-	T	-	-	-	-	-	-	T	MT	T	T	-	T	-	-																	34	10	22.7
16	2	F			C	CT	CC	D	DC	C	C	TC	C	DD	C	CC	T	CC	D	DC	C	T	D	D	-															4	28	87.5
17	3	M			T	CC	MT	CC	C	-	T	C	-	-	T	D	CC	-	TMT	CA	-	-	C																		17	19	52.5
18	4	M			C	D	C	-	MT	C	A	C	A	-	MTD	CC	T	-	D	D																					12	15	55.5
19	6½	M						MT	DT	T	TT	TMT	TD	TC	-	-	T	TA	AT	CT	TD	-	D	C	D	DC	-														13	26	66.6
20	10	M			-	-	-	MT	MT	-	-	-	-	-	-	MT	-	-	-	MT	-	-	-	-	-	T															36	5	12.2
21	6	M					-	DD	TD	T	D	-	-	T	-	-	T	-	-	CD	D	MT	T	-	-	-															26	13	33.3
22	9	M			D		T				T			T	T		T																							28	6	16.6
23	14	M																T	T				C																	33	3	8.3
24	9	M		MT	T	-			T				TD																											19	5	20
25	10½	M				MT								T				A																						33	3	9
26	5	M		D		T	TT	TT			T			DMT		TT	C	D	C	T		T	MT																	25	17	40
27	8½	F											T	D		T		T			T	-																		29	5	15
28	7	M	T					D		MT			T	T	MT	C																								20	7	26
29	5	F	-	-	C					C																														34	2	5.5
30	12	F																																						32	-	0
31	2	F				CMT			CMT			T	T	T		MT	C	T	T	T	MT	C	T																	15	15	50
32	9	F					T	T			T	T	T	T					TT																					24	8	25
33	8	F							DT	C							D	T	T																					22	6	21.4
34	7	F		C			MT			MT			C	C				MT																							24	6	20
35	10	F	D							D						D																								33	3	8.3

APPENDIX, TABLE, I., Details of Observations on the reducing power of the Urine in 66 Cases of Whooping Cough

A = Abundant, C = Considerable, D = Distinct T = Trace, M.T. = Minute Trace.

Approximate Day of Illness

No.	Age	Sex	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	7	F					-	-	T	-	T	-	T	-	MT	DMT	T	DMT	MT	MT	T	-	-
2	5	F												T	-	-	TCD	CTD	DDD	C	-	DDMT	MT MT
3	3	M					-	-	MT	TT	DT		DD	D	DD	T	-	T	-	3MT	T	-	MT
4	4	F																					
5	9	F																			D	MT	-
6	2	M												DD	D	TMT	DT	MT	T	MT	TTT	-	-
7	4	M												DDDD	DDDD	DDDD	DDDD	DDDD	D DDDD	D DDDD	DD	D DDDD	TTTD
8	6	M																					
9	4	M													TT	TMT	MT	MT	D	TTD	DDD	TTD	TTT
10	3	F					D	TD	TDD	DT	-	T	TDD	DD	DD	D	D	TT DDDD	TT	TTTD	T MT MT	MTDD	TDDD
11	7	F												D	DDD	DD	DD	MT TTT	T	DT	DDD	TTDD	3MT
12	6	F												TT	4MT	3MT	T	MTMT	TTT	2MT TT	TTTT	T 3MT	D 4T
13	5	F												-	D 2MT	4T 2MT	4T	2D	3T	3D	2D	2T 4MT	4T 2D
14	5	F												4T	5T	D 3T	4T	MT 3DT	3T 2MT	D	T 5MT	3MT 2D	MT
15	5	M												2T MT	3T 2D	2T MT	TMT	MT	-	D	MTD	T	-
16	6	M												3T	3D 3T	3D 3T	T	2T 2D	6D 2T	3D MT	2D	DMT	MT
17	6	M												2D	DMT	-	-	-	-	-	TD	-	-
18	7	M											T	D	-	-	-				T	D	T
19	4	M											T	D	-	-	-	T	T	T	T	-	T
20	6	M												C	TDC	2D	2C	DC	CT	2D	T	MT	3D
21	2½	M	T	MT	D	-	-	-	-	-	-	-	-	-	-	-	MT	MT	T	T	MT	-	-
22	2½	M	T	DT	TT	T	-	-	-	T	-	-	-	T	T	2D	TD	T	CT	CMT	T	D	DT
23	7/12	M	D	DT	D	-	2T	2T	DMT	2T	T	MT	T	DT	-	D	DT	D	-	MT	T	T	T
24	4	M	T	-	-	-	-	-	T	-	T	-	-	2T	-	TMT	-	-	-	-	-	-	2T
25	9/12	M	-	D	T	TMT	2T	T	T	TMT	-	T	MT	MT	T	D	T	-	-	-	-	-	-
26	4	M																					
27	5	F																					
28	3	F																					
29	4	F																			T	D	TT
30	3½	F																				DMT	TT
31	6½	F																			TT	MTD	T
32	3	M																					
33	6	M																T	TD	DD	DD	TD	T
34	4	M																			DD	CC	CC
35	5	M												T	DD	DD	TD	D	TD	TD	T	DD	TD
36	5	F																					
37	5	M																			D	AA	DD
38	5	M																					
39	6	M															C	CC	CT	D	D	T	D
40	3½	F																		T	D	DD	DD
41	6	F																					
42	4	F																			D	T	
43	3	M																			TT	TT	TT
44	3½	F																				TD	T
45	3	M																			T	TD	TT
46	4	F																					
47	6	F														T	T		T		T	T	T
48	3	F																					
49	6	F													D	T	T	D	C		D		TD
50	2	F																		D	T	T	MT
51	3	M																					
52	5	M																					D
53	5	M																T	TD	DC	DC	TC	D
54	6	F																					
55	7	M																					
56	3	F																				D	TT
57	3	F																				T	D
58	5	M																					
59	5	M																					
60	6	F																D	T	T	TD	T	TD
61	4	F															C	D	T	T	TD	T	
62	3	M												TD	D	T	TT	TC	TD	T	T	T	TD
63	4½	M																			T	T	T
64	6	F																			T	TD	T
65	3	F																			CT	DT	T
66	4½	F																TD	T	TT	TD	D	TD

No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
1	T	-	MT	MTT2	-	-	T	-	-	TT	-	T	-	T	-	-	-	-	-	-	-	-	-	-
2	T	MT TCTT	MT	MT	DDT	T DMT	3D 4T	TT	TT	MT	T	-	-	-	T	-	MT	T MTMT	D	-	-	-	-	
3	-	-	-	MT	MT	MT	-	T	TTT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4																		-	-	-	T	-	-	MT
5	T	-	-	-	MT	-	-	T	-	-	-	-	-	-	-	-								
6	-	-	T	-	-	-	-	-	-	-														
7	DDT	D DDDD	DTT	TDD	TTD	TTTT	DDT	TTT	MT TTT	T DDDD	MT DD	D DDDD	D	MT MT MT	DT	DDD	TTTD	DD DDDD	DDD	DDDD DDD	TDD	DD DDDD	TTTD	TTD
8												D	T	-	-	TT	TT	D	DD	DDD	-	-	DDD	DDD
9	MT TD	MT TD	TT	MT DMT	DT	TDD	TTD	DD	TTT	TTTT	D TTTT	DT	DD DDDD	T	TD	MT	-	-	-	-	-			
10	DDDD	DD	MTD	MT MT DDD	MT MT D	DD TTT	TT 4MT	TD	DD TTT	TTT DDDD	TTT DD	TT TTTT	MT TTTD	MT TTD	MT TTD	DD	MT	TDD	MT TTDD	DD	T	MT	DDT	DDT
11	DT	T	TTDD	MT DTT	DD	DD	TMT DDD	TTTT	TTMT DDD	MT DDD	6T DDD	DD MT	D	MTMT	4D	2TTMT	DD TTT	TTT	MT	DT MT	T	DT	TMT	-
12	MT 3T	4T	2D 2T	D 2MT 2T	D	6T	2T	5MT	TMT	TD	T	4T	-	-	T	T	-	DD	MT	D	2MT	-	-	-
13	4T 2MT 3D	3T 7D	6D 6T	7D T	T 4D	5D 3T	2D 7T	MT 4T 2D	2T D	T 3MT 2D	2D T	MT 2D	2T MT 3D	D 2T MT	MT	2D	T	-	TMT	T 3MT	DT	4MT T	D	MTD
14	-	-	-	-	2T	2T	-	2MT 5D	T 5D	C MT T3D	3D T	MT 2CT	TMT	TMT	4D C2T	D	C2D	TD	2MT	T	D	MT	-	-
15	T	D	-	-	-	T	-	T	2MT	-	MT	-	2T	D	-	-	-	2D 2T MT	2D	-	2MT	-	T	-
16	-	-	-	-	-	-	TD	TDC	3D	-	D	C 2T 2D	-	2D T MT	TD	DMT	D	DMT	T	2MT	3DT MT	MT 2TD	-	-
17	-	T	D	-	2C MT	MT	2T	-	-	-	-	-	-	-										
18	T	2T	2T	T	T	-	-	TD	T	-	-	-	-	-	-									
19	D	TD	-	-	-	-	-	-	-	-	-	-												
20	DT	TD	2D	TD	3D	T	2T	2D	TD	-	-	-	-	-	-	-								
21	-	MT	-	MT	-	-		T	-	T	T	-	-	-	-	T	-	-	T	MT	T	MT	MT	-
22	2MT	2C	TC	MTT	T	CT	TD	DC	TMT	TMT	-	CMT	T	-	-	T	MT	-	-	-	-	-	DT	T
23	TMT	-	-	T	-	-	T	-	T															
24	2T	T	T	DT	MT	MT	T	MT	-	MT	-	-	-	-										
25																								
26					D	T	T	DT		D	TD	TD	D	T	T	MT	DT	D			T	MT	D	
27				MT	MD	D	DT	T	DT		TT	D	T	DT	D		D	T	DT					
28								MT	D	C	MT	C	D	T	DT	T	TD	MTD	T	D	D	TD	MT	
29	T	MT		MT	T	MT	T	T	TD	D	T	MT			T									
30	D	TD	D	D	D	MT	TT	T	TD	D	D	T		MT	TT	D	T	TD		T				
31	T	TT	MT	D	T	T	TT	MTD	T	TMT	TD													
32					TT	T	TD	T		TT	T	T	D	TT	T	MT	TD	T	TT	T		TD	D	DT
33	D	T	D	T	TD		T		MT	D	T		MT											
34	CT	C	TD	DD	T	T	C	D	TD	TD	D	TT	C		D	TD	T	T						
35	CT	T	TD		T	D	TD		D		T	D												
36			DT	TD	DT	T	D	DD	D	T	DT	D	TD	T	D	TD	TT	D	TT	D	TT		T	
37	CC	CC	CD	DD	DD	TD		C	T		T													
38								DD	T	D	T	T	D	DT	T	TD	T	TD	D	D	TD	D	TD	T
39	D	TD	TD	D	TD	TT	TT	TD	T	TD	T	TD	D		TD	DT								
40			D		T	T	D			T	D	T		T	MT									
41					DD	TT	TC	T	D		D	TT	C	T	D	TD	D		D		T	T		
42		D	T	D	MT	MT			T	T	MT		T	T	MT	T								
43	D	TD	TD	D	T		T	TD	T	TD	T	D		T										
44	T	T	T	D	D	TD	T	D	T	TD	T	TD	D	T										
45				D	T	TD	TD	T	T		T	T	TD	T	T		T							
46		T		T		T		D	T	D	TD	T	T	D		T		T	TT	T		MT		
47	D	TD	T	T	T	MT		T		T														
48												C	T	MT	MT	T	MT	T	D	T	T	MT	MT	T
49	T	T	TD	D	T	MT	T	D	MT	D		TT	T	D		T	T							
50	D	D	D	T	MT	D	T	T	D	D	TD	TD	T	D				T	MT					
51			T	D	D	T	T	D	T	T	D		T	T	D	T	T		D	MT				
52		T	D	T		T	D	D	TD	T	MT	T	T		D	MT	MT							
53	T	DT	C	T	TT	TC	D	TD		D	DT													
54				T		T	T	T		T	TT	T	D	T										
55												T	T	T	MT	MT	TT	TMT	T	MTT	T	T	T	D
56	TT	TC	T	T	D	TT	TT	D	C		D	DT	T	MT				D		MT				
57		T	T	T		C	D	T	T	T	D	T		MT										
58				T	T		T	T	MTT	MT	MT	TT	MT	TD	MT	D	MTT		T	MT				
59					C	C	D	T	T	MT		T	MT	MT	T									
60	T	T	T	MT	MTT	TT	T	T	T	TT	T		MT											
61		T		T	TT	MT	T			MT														
62	TD	D	C	DT	T	T	D	T	T	MTT		T	TT	MT										
63	T	T	T		MT		T	MT		T														
64	TD	T	T	T	D	TD		MTT	T		T	MT	MT	T										
65	TD	TD	D	TT	D	TD	T	TD	T	TD	T	D	T			T			MT					
66	TD	TT	T	TD	T	D	T	D		TD	MT		MT	T										

No.	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
1																						
2																						
3																						
4	MT	-	2MT	-	-	-	-	-	-	-	T											
5																						
6																						
7	TTTD	MT TTT	TTDD	TTT DDDD	TTDD	T DDDD	MT	TTT	T	TMT	-	-	TT	-	TMT	-	-	-	-	-		
8	TTT	DMT	D	D	T	D	-	-	-	-												
9																						
10	T	-	-	-	-	-	-	-	MT	D	MT MT TT	-	T	MT	MTD	C	CT	T	MT	T	T	T
11	MT	TMT	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
12	-	-	-	-																		
13	MTD	3C D	D	-	-	-	3MT D T	-	-	2MT	2T	MT	T	T	-	-	-	-	-			
14	-	-	-	-																		
15	-	-	-	-	-																	
16	-	-	-	-	-																	
17																						
18																						
19																						
20																						
21	-	-	-	-	-	-																
22	2D	MTC	MT	2D		T	T	2D	2T	MT	2T	MT	-	-	DC	T	2T	D	T	-	T	T
23																						
24																						
25																						
26																						
27																						
28																						
29																						
30																						
31																						
32	MTD	T	TD	T																		
33																						
34																						
35																						
36																						
37																						
38	T	D																				
39																						
40																						
41																						
42																						
43																						
44																						
45																						
46																						
47																						
48	T																					
49																						
50																						
51																						
52																						
53																						
54																						
55	T		MT	TMT																		
56																						
57																						
58																						
59																						
60																						
61																						
62																						
63																						
64																						
65																						
66																						

No.	Total Samples	No Reduction Day	No Reduction Night	Reductions Day	Reductions Night	Proportion of Reductions per cent.
1	157	85	48	9	15	15.3%
2	95	24	16	30	25	58
3	110	41	47	12	10	20
4	29	12	13	2	2	14
5	32	14	13	3	2	16
6	34	8	12	8	6	41
7	234	38	38	80	78	67.5
8	83	32	24	15	12	32.5
9	155	53	35	30	37	43
10	383	153	99	53	78	34
11	229	68	50	45	66	48.5
12	228	80	68	29	51	35
13	245	104	47	44	50	38.4
14	203	106	59	17	21	18.5
15	220	107	38	32	43	34
16	142	86	43	5	8	9
17	58	32	13	6	7	22
18	56	26	14	12	4	28.5
19	328	66	86	78	98	53.7
20	53	10	5	24	14	71.5
21	97	39	38	10	10	20.5
22	132	31	25	35	41	57.5
23	58	15	11	14	18	55
24	62	22	18	8	14	35.5
25	26	5	3	7	11	70
26	96	40	36	7	13	21
27	90	33	37	12	8	22.3
28	80	32	36	7	5	15
29	96	40	39	8	9	17.5
30	88	36	25	7	20	30.7
31	72	32	20	6	14	28
32	88	32	26	12	18	34
33	96	38	37	9	12	21.9
34	100	30	40	20	10	30
35	108	45	34	12	17	26.8
36	96	32	34	17	13	31.2
37	80	32	28	10	10	25
38	84	32	27	10	15	30
39	72	17	21	20	14	47.2
40	80	36	29	5	10	18.7
41	72	28	24	9	11	27.8
42	48	18	16	7	7	29.8
43	84	32	30	10	12	26.2
44	95	41	33	7	14	21
45	81	33	27	8	13	26
46	90	35	38	10	7	18.8
47	62	27	20	5	10	24.8
48	72	31	27	6	8	20
49	100	43	32	12	13	25
50	80	32	26	10	12	27.5
51	52	21	15	6	10	31
52	52	21	15	5	11	31
53	81	31	25	10	15	30.8
54	64	29	25	4	6	15.6
55	72	28	24	12	8	27.7
56	80	30	27	10	13	28.7
57	56	24	19	6	7	23.2
58	64	25	20	8	11	29.7
59	40	17	13	4	6	25
60	90	36	31	10	13	25.5
61	94	42	38	7	7	15
62	91	34	25	12	20	35.2
63	63	28	25	5	5	15.8
64	80	37	24	8	11	23.7
65	91	36	29	10	16	28.5
66	91	49	26	12	14	28.5