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APPROXIMATELY COMPLETE ANALYSES OF THIRTY "NORMAL" URINES.

BY OTTO FOLIN.

[FROM THE CHEMICAL LABORATORY OF THE MCLEAN HOSPITAL FOR THE INSANE, WAVERLEY, MASS.]

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[*From the Chemical Laboratory of the McLean Hospital for the Insane, Waverley, Mass.*]

TOTAL nitrogen. — Kjeldahl's method was applied as follows: 5 c.c. of urine are measured out by means of small burettes (with glass stopcocks) graduated in twentieths of a cubic centimetre, 20 c.c. sulphuric acid, and a small quantity of copper sulphate + potassium sulphate are used for the decomposition, the boiling being continued about one-half hour. The normal acid and alkali from which the tenth normal solutions are obtained, are prepared with sodium bicarbonate (made from sodium) as control. "Alizarin red" is used as indicator. Numerous duplicate determinations have convinced me that this procedure gives perfectly reliable results with urine.

It may be permissible to point out in this connection that the conversion of the urinary nitrogen into ammonia by means of sulphuric acid involves very little oxidation. It is essentially a hydrolytic reaction, and not an oxidation.[1]

Urea.[2] — The method used in this laboratory is as follows: 5 c.c. of urine are measured into an Erlenmeyer flask (capacity, 200 c.c.), 5 c.c. concentrated hydrochloric acid, 20 gm. crystallized magnesium chloride, a piece of paraffine the size of a small hazelnut, and finally two or three drops aqueous, 1 per cent solution of "alizarin red" are added. The safety tube described in my second paper on the subject is then inserted, and the mixture boiled until each returning drop from the safety tube produces a very perceptible bump. The heat is then reduced somewhat, and the heating is continued for a full hour.

Particular attention must be called to the addition of the indicator

[1] MALFATTI: Zeitschrift für physiologische Chemie, 1903, xxxix, p. 469; FOLIN: *Ibid.*, 1904, xli, p. 239.

[2] FOLIN: Zeitschrift für physiologische Chemie, 1901, xxxii, p. 504; 1902, xxxvi, p. 333; 1903, xxxvii, p. 548; MÖRNER, K. A. H.: Skandinavisches Archiv für Physiologie, 1903, xiv, p. 297.

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alizarin red, as its use in this combination has not been described before. This indicator is so stable as to withstand the heat, and it turns bright red in the presence of the smallest trace of alkali. The boiling contents in the Erlenmeyer flask must not be allowed to remain alkaline, and as soon as they begin to turn red, a few drops (but only a few) of the acid distillate in the safety tube are shaken back into the flask. At the end of an hour the contents of the flask are put into a litre flask with about 700 c.c. water and 20 c.c. 10 per cent sodic hydrate, and the ammonia distilled off. This distillation must be continued until the contents of the litre flask are nearly dry, or till the distillate shows no trace of ammonia with delicate litmus paper (about one hour). The distillate is then boiled a few minutes to drive off the carbonic acid, cooled and titrated in the usual manner. Alizarin red is used as indicator. It is very serviceable in all cases where moderate quantities of ammonium salts are present.

This procedure is believed to give highly accurate and reliable results. The combination of this method with the Mörner-Sjöquist method, as described by Mörner, *loc. cit.*, must be used with urines containing sugar, because when carbohydrates and urea are heated together they combine, according to Schoorl[1] into very stable condensation products, the ureids. Sugar was absent in the urines here investigated. I have, however, several times applied the combination of the two methods, but with practically identical results.

The highest degree of accuracy is of course the most important point in connection with any analytical method, but as long as scientific investigations are still largely limited to more or less isolated individual efforts, it will be necessary at times to sacrifice the last degree of accuracy for the sake of saving time. The extraordinarily careful work of Mörner would seem to indicate that the combination method which he used was a trifle more accurate than my method taken by itself. I freely acknowledge that this may well be the case, and that Mörner's urea values represent the highest degree of accuracy at present obtainable. The only reason why I hesitate to accept this conclusion as quite beyond question is the fact that the accuracy of Mörner's figures obtained by the combination method depends upon the accuracy of his ammonia determinations. The latter were made according to Schlösing, but the important details upon which the

[1] SCHOORL, N.: Chemisches Centralblatt, 1903, lxxiv, p. 1079.

accuracy of Schlösing's method depends cannot be said to have been at all well-known prior to the publication of Shaffer's paper[1] on the subject in 1903. The method is at best only moderately accurate, and if used according to the directions given in textbooks of physiological chemistry and urine analysis, the results are far from correct. Leaving sugar urines out of consideration, it is therefore not quite excluded that the small differences in the results of the two procedures may at least in part be due to inaccuracies in the ammonia-determinations. The fact that duplicate Schlösing determinations were made, furnishes very little additional guarantee of accuracy even in the hands of such a skilled and careful investigator as Mörner. Be this as it may, and accepting the differences which Mörner found as being in favor of the combination method, they are in the case of normal urines so small (most frequently no difference at all) that I have not hesitated to continue the use of the urea-determinations as described above. The saving of time and attention is of no small importance when a consecutive series of urines are to be as completely analyzed as has here been the case, and the combination method used by Mörner requires much more time, as well as more continuous attention than the simple method here used.

Ammonia.[2] — The ammonia is set free by the addition of a weak alkali (sodic carbonate), is then removed from the urine at ordinary room-temperature by means of a strong air current, collected in tenth normal acid, and titrated.

25 c.c. of urine is measured into an aerometer cylinder (30–45 cm. high), and about a gram of dry sodic carbonate and some crude petroleum (to prevent foaming) are added. The upper end of the cylinder is then closed by means of a doubly perforated rubber stopper, through which pass two glass tubes, only one of which is long enough to reach below the surface of the liquid. The shorter tube (about 10 cm. in length) is connected with a "calcium chloride tube" filled with cotton, which in turn is connected with a glass tube extending to the bottom of a wide mouth bottle (capacity about 500 c.c.) which contains tenth normal acid (20 c.c.), water (200 c.c.), and indicator for the absorption of the ammonia. The complete absorption of the ammonia is most easily insured by the use of a simple but effective absorption tube which compels a very intimate

[1] SHAFFER: This journal, 1903, viii, p. 331.

[2] FOLIN: Zeitschrift für physiologische Chemie, 1902, xxxvii, p. 161; SHAFFER, this journal, 1903, viii, p. 330.

contact of the air coming from the cylinder with the acid and water in the absorption bottle. For a description of this tube the reader is referred to the original paper (*loc. cit.*, p. 169). It is easily made, but it can also be obtained from Eimer and Amend (New York). The air passing first through the alkaline urine, and then through the standard acid, transfers every trace of ammonia in the course of a relatively short time ($1\frac{1}{2}$ hours) from the urine to the acid, and is then determined by direct titration.

For the accuracy of this method I can vouch. The air current must, however, be rapid (several hundred litres per hour). An ordinary good filtering pump, or better an inverted filtering pump, a blast pump, is sufficient if the water-pressure is not too low.

Kreatinin.[1] — The principle upon which this determination is based is the color-reaction given by kreatinin, and by no other normal urinary constituent, with picric acid in an alkaline solution. In order to make the color-comparisons accurate enough for quantitative purposes a high grade colorimeter is necessary. The French instrument of Duboscq, obtained through Eimer and Amend, is eminently satisfactory. Its construction and workmanship are excellent, the prisms are perfectly flawless, and the height of each solution can easily be adjusted to within an accuracy of a tenth of a millimetre.

Half-normal potassium bichromate containing 24.55 gm. per litre, saturated picric acid solution containing about 12 gm. per litre, and 10 per cent sodic hydrate solution are the reagents needed.

10 c.c. urine is measured into a 500 c.c. volumetric flask, 15 c.c. picric acid and 5 c.c. sodic hydrate are then added, and the mixture is allowed to stand for five to six minutes. This interval is used to pour a little of the bichromate solution into each of the two cylinders of the colorimeter. The depth of the solution in one of the cylinders is then accurately adjusted to the 8 mm. mark. With the solution in the other cylinder a few preliminary colorimetric readings are made simply for the sake of insuring greater accuracy in the subsequent readings of the unknown solution. The two bichromate solutions must of course be equal in color, and in taking their readings no two should differ more than 0.1 mm. or 0.2 mm. from the true value (8 mm.), leaving out of consideration the very first reading made, which is sometimes less accurate. Four or more read-

[1] Folin: Zeitschrift für physiologische Chemie, 1904, xli, p. 223.

ings should be made in each case, and an average taken of all but the first. After a while one becomes very sure of the true point, and can take the average of the first two readings.

At the end of five minutes the contents in the 500 c.c. flask are diluted up to the 500 c.c. mark. The bichromate solution is thoroughly rinsed out of one of the cylinders by means of the unknown solution and several colorimetric readings are then made *at once.*

The calculation of the results is very simple. If, for example, it is found that it takes 9.5 mm. of the unknown urine-picrate solution to equal the 8 mm. of the bichromate, than the 10 c.c. of urine contains $10 \times \frac{8.1}{9.5} = 8.4 +$ mg. kreatinin.[1]

The amount of urine taken for the determination is usually 10 c.c., but if this should be found to contain more than 15 mg. or less than 5 mg. kreatinin, the determination should be repeated with a correspondingly different amount of urine, because outside of these limits the determination is much less accurate. With kreatinin solutions, the results are uniformly surprisingly accurate, and I have as yet found no reason for believing that the method is not equally reliable, at least for normal urines. The color of the urine does not materially affect the result on account of the very great dilution.

A kreatinin-determination can be made by this method in less than fifteen minutes.

Uric acid.[2] — The uric acid determinations are carried out as follows:

The chief reagent is a solution of 500 gm. ammonium sulphate, 5 gm. uranium acetate, and 60 c.c. 10 per cent acetic acid in 650 c.c. water.

150 c.c. urine is measured into a tall, narrow beaker, or a cylinder, and $37\frac{1}{2}$ c.c. of the reagent is added (if the available quantity of urine is not too small, 200 c.c. urine and 50 c.c. reagent are used). The mixture is allowed to stand without stirring for about half an hour. The uranium precipitate has then settled and the clear supernatant liquid is removed by siphoning or by decantation. 125 c.c.

[1] The calculation is based on the experimentally determined fact that 10 mg. of perfectly pure kreatinin, give under the conditions of the determination 500 c.c. of a solution, 8.1 mm. of which has exactly the same colorimetric value as 8 mm. of half-normal bichromate solution.

[2] FOLIN and SHAFFER: Zeitschrift für physiologische Chemie, 1901, xxxii, p. 552.

of this liquid is measured into another beaker, 5 c.c. strong ammonia is added, and the mixture set aside until the following day. The precipitate is then filtered off, washed with 10 per cent ammonium sulphate solution until the filtrate is quite or nearly free from chlorides. The filter is removed from the funnel, opened, and the precipitate rinsed back into the beaker. Enough water to make about 100 c.c. is added, and finally the precipitate is dissolved by means of 15 c.c. concentrated sulphuric acid, and at once titrated with $\frac{n}{20}$ potassium permanganate solution, each c.c. of which corresponds to 3.75 mg. uric acid. A correction of 3 mg., due to the solubility of the ammonium urate, is added to the result. The very first pink coloration, extending through the entire liquid from the addition of two drops permanganate solution, while stirring with a glass rod, marks the end point of the titration.

Chlorides. — The chlorides are titrated according to Volhard, and the only point that need be mentioned is the fact that a fair amount of nitric acid must be added in order to get a clear filtrate.

Phosphates. — The phosphates are determined volumetrically by means of uranium acetate solution, using powdered potassium ferrocyanide as indicator. Chemically pure crystallized monopotassium-phosphate is used to standardize the uranium solution.[1]

Total sulphur and sulphates. — A few general remarks concerning sulphate precipitations in urine may not be unnecessary. To get correct results, it is indispensable that the barium chloride be added very slowly to the hot acidified urine. If the barium is added too rapidly the precipitate will invariably carry down other salts which the subsequent washings with hot water will not remove. To illustrate:

Urine A, 0.50 c.c. + 25 c.c. $BaCl_2$, added in about thirty seconds gave 0.2759 gm. and 0.2780 gm. barium sulphate. The same urine, with the barium chloride added by means of a capillary funnel (made from a calcium chloride tube) so constructed as to deliver 25 c.c. in five to seven minutes, gave 0.2713 gm. and 0.2693 gm. barium sulphate.

Urine B. gave under similar conditions by the first procedure 0.4032 gm. and 0.4052 gm. barium sulphate, and by the latter procedure only 0.3897 gm. and 0.3900 gm. barium sulphate.

Among the sulphur constituents of urine there are very minute

[1] See SUTTON's Volumetric Analysis, 8th ed., p. 316.

quantities of substances which can scarcely be determined separately, but which are included in the total sulphur, and which must therefore be counted as inorganic, ethereal, or as neutral sulphur. Such substances are traces of hydrogen sulphide very frequently present in urine, and the sulphocyanides which are probably always present. In the scheme of analysis here followed, these substances are included in the ethereal sulphates, not because they belong there, but it is most convenient not to exclude them in the ethereal sulphate determinations. This arrangement has in a measure proved unfortunate, because of the unexpected importance which the ethereal sulphates have acquired in the course of these investigations, an importance which was not at all foreseen at the time the analytical scheme was adopted. That the errors in the ethereal sulphate determinations due to this fact are not important enough to vitiate the conclusions drawn, is shown by the following determinations made with and without the use of potassium chlorate. The analyses were made in urines representing the eighth, ninth, and tenth days of a starch and cream diet described in the next paper.

Urine	A,	133	c.c.	with	the use of $KClO_3$ gave	45.8	mg.	$BaSO_4$.
"	"	"		without	" " "	37.6	"	"
"	B	"		with	" " "	43.8	"	"
"	"	"		without	" " "	34.7	"	"
"	C	"		with	" " "	41.1	"	"
"	"	"		without	" " "	34.1	"	"

Inorganic sulphates.[1] — To 50 c.c. of urine in a (200 c.c.) Erlenmeyer flask are added 5 c.c. of a 4 per cent potassium chlorate solution and 5 c.c. concentrated hydrochloric acid. When this mixture has boiled a few minutes (5–10) it is perfectly colorless. The capillary dropping funnel (described above) is then inserted, and the barium chloride (25 c.c. 10 per cent solution) is poured into the funnel. After a few minutes, the heat is reduced to below the boiling point, and the mixture kept at this temperature for one-half to one hour. The barium sulphate is washed for half an hour with hot water, and at intervals of a few minutes hot ammonium chloride solution (5 per cent) is substituted for the water, so that in all five or six additions of ammonium chloride take place in the course of the first twenty minutes of the washing. Filter-paper and

[1] FOLIN: This journal, 1902, vii, p. 152.

precipitate are then at once partially dried by folding and pressing gently between dry filter-papers, and are then transferred to the weighed porcelain crucible. 3 or 4 c.c. of alcohol are poured into the crucible and ignited. This dries and partially burns the filter-paper, and the residue is then burned to whiteness, cooled and weighed. The weight of the ethereal sulphate precipitate, separately determined, is subtracted from the result.

Ethereal sulphates. — 200 c.c. of the urine, previously diluted to 1 litre if necessary, is measured into a beaker, and 100 c.c. barium chloride solution (10 per cent) added in the cold. The mixture is set aside for twenty-four hours, and the clear supernatent liquid poured into a second dry beaker by decantation. This preliminary decantation is necessary, because the barium sulphate precipitate will otherwise go through the filter. The decanted liquid is filtered, and 150 c.c. of the clear filtrate, corresponding to 100 c.c. of urine, is measured into an Erlenmeyer flask (capacity 400 c.c.), 10 or 15 c.c. concentrated hydrochloric acid, and 10–15 c.c. 4 per cent potassium chlorate are added, and the mixture is heated to boiling. The remainder of the operation is similar to that described for the inorganic sulphate determination.

Total and neutral sulphur. — The total sulphur is determined in the urinary residue burned in the presence of 0.3–0.5 gm. potassium carbonate and previously titrated for the "mineral acidity." It may seem questionable whether the urinary residue can be burned in the presence of such small quantities of alkali without loss of sulphur. The oxidation is, however, in this case a slow process, and is therefore free from the dangers that prevail when the carbonate-nitrate fusion mixture is used. A series of comparative determinations made to test the accuracy of the method have shown the results to be very reliable, and incidentally have shown that the ignition with the fusion mixture does not give correct results unless large quantities are used. This is shown by the following figures:

Ignition with K_2CO_3.	Ignition with Fusion Mixture.
0.297 gm. = 0.1366 gm. $BaSO_4$	About 3 gm. = 0.1335 $BaSO_4$
0.377 gm. = 0.1365 gm. "	" 3 gm. = 0.1358 "
0.291 gm. = 0.1370 gm. "	" 6 gm. = 0.1372 "
0.342 gm. = 0.1366 gm. "	" 6 gm. = 0.1372 "
	" 10 gm. = 0.1375 "
	" 9 gm. = 0.1390 "

If the mineral-acidity determinations are not to be made, the nitrate-fusion-mixture method, or better still, the sodium peroxide method, is the more convenient; but where such acidity determinations are made, it would be useless loss of time to ignite a separate sample of urine for the sulphate determinations. (For details of evaporating and igniting the urine with small quantities of carbonate alone, see the mineral-acidity determination.)

From the total sulphate as obtained by this process are subtracted the inorganic and the ethereal sulphates, in order to get the "neutral" sulphur of the urine.

Indican. — The indican-determinations recorded in this paper will need a somewhat fuller explanation, because the method used for recording these values is wholly arbitrary. Exactly one-hundredth of a twenty-four-hour quantity of urine is taken for each determination. In this the indigo is developed by the addition of Obermeyer's reagent, and the indigo-blue taken out by means of 5 c.c. chloroform. With the chloroform solutions are then made colorimetric comparisons, using Fehling's solution as a standard. The Fehling's solution is given the arbitrary value of 100.

The advantage of this method is that it takes very little time, and the standard for comparison is one that is kept on hand in every laboratory.

It has been my intention to work out an exact method on this principle, by using the same colorimeter as is used in the kreatinin-determinations for the color comparisons, and then finding the value of Fehling's solution in terms of pure indigo. The difficulties in the way of such a colorimetric method are by no means small, the chief of which is to produce a pure blue solution from the indican without any admixture of red coloring matter.

The method as described gives sufficiently definite values to enable any one to repeat the experiment, and get comparable values; but it does, of course, in the present form, not possess the accuracy that would entitle it to be classed as quantitative.

Total Acidity.[1] — To 25 c.c. of urine are added 15–20 gm. powdered potassium oxalate, and one or two drops of a 1 per cent phenolphtalein solution. The mixture is shaken rapidly for one or two minutes, and titrated at once, *i. e.*, while still cold from the effects of the dissolved oxalate, until a faint but unmistakable tint remains permanent on further shaking.

[1] FOLIN: This journal, 1903, ix, p. 265.

Mineral acidity or the excess of mineral acids or bases.[1] — Bunge,[2] Magnus-Levy,[3] Soetbeer,[4] and many others have studied the balance of the acid and basic forming elements in urine by means of separate determinations of all the different metals and acids. Here the same result is obtained by direct titration of the burned urinary residue.

To 25 c.c. of urine in a platinum dish is added from 0.3 to 0.5 gm. K_2CO_3, weighed within an accuracy of two-tenths of a milligram. The solution is evaporated to dryness, and the residue ignited, when perfectly dry, over a radial burner using at first a very low heat, and at no time allowing the dish to become more than faintly red hot. The dish is heated at this temperature for one hour, then cooled, and 10 c.c. of hydrogen peroxide is added and evaporated. The dried residue is ignited as before for one hour. It is dissolved in an excess of tenth normal hydrochloric acid and water (50–75 c.c. $\frac{n}{10}$ HCl), transferred to an Erlenmeyer flask, boiled to remove carbonic acid, and cooled. One or two drops phenolphtalein solution and a few crystals of neutral potassium oxalate (to precipitate the calcium) are added, and the solution is titrated as usual. The ammonia, the acidity of the hydrogen peroxide, and the acidity of the organic sulphur (neutral and ethereal, 8 gm. of which are taken to represent 1 c.c. tenth normal acid) must be subtracted from the result given by the direct titration. These values, as well as the acidimetric value of the potassium carbonate, must be separately determined.

This procedure gives very reliable results, if proper care is used in the evaporation and the burning of the urine. It is to be used only when the actual excess of mineral acids above that necessary for the neutralization of the mineral bases is to be estimated, or when the total amount of organic acids in urine (whether free or combined with bases) is to be determined.

For the determination of the *free* mineral and organic acidity, titrate the total acidity as described above, then determine the phosphates, and subtract their acidimetric value (1 c.c. tenth normal acid for each 7.1 mg. P_2O_5) from the total acidity. The remainder is the acidity due to uncombined organic acids, and the difference,

[1] Folin: This journal, 1903, ix, p. 270.

[2] Bunge: Physiologie des Menchen, 1901, p. 420.

[3] Magnus-Levy: Archiv für experimentelle Pathologie und Pharmakologie, 1899, xxxxii, p. 149.

[4] Soetbeer: Zeitschrift für physiologische Chemie, 1902, xxxv, p. 96.

that obtained from calculating all the phosphoric acid as diacid phosphate, is the free mineral acidity. If the acidity calculated from the total phosphates is greater than the titrated acidity, then there are practically no free organic acids present, and the titrated acidity represents the amount of phosphates present in the diacid form. Urines of the latter kind are turbid, unless they are also practically free from calcium.

A more detailed discussion of the acidity of urine will be given in the next paper, entitled Laws governing the Chemical Composition of Urine.

II. The Composition of "Normal" Urine Corresponding to a "Standard Diet."

Almost every textbook on physiology and on physiological chemistry gives a sample table to illustrate the composition of normal human urine. Most English textbooks give the table formulated by Parkes a generation ago, and all textbooks that I have had the opportunity to examine cite the same kind of tables now as were cited twenty years ago, *i. e.*, before the introduction of Kjeldahl's method for determining nitrogen. All omit the total nitrogen which the tables are supposed to represent. Yet it was by the help of Kjeldahl's method that Pflüger in 1886 made the important discovery that urea constitutes only about 87 per cent of the total nitrogen, and it is only on the basis of the total nitrogen that percentage studies of the different nitrogenous constituents of urine are possible.

In view of these facts, and in view of the fact to which Bunge has called attention in the different editions of his textbook, that in all the voluminous urine literature there is still no record of the complete analysis of any one concrete sample of a normal twenty-four-hour quantity of urine, I present in Tables I–VII the records of thirty fairly complete analyses.

In Schäfer's textbook of physiology (Vol. I, p. 573) Hopkins, in commenting on two analyses of Bunge's, points out that no great importance can be attached to such collective quantitative analyses of urine unless the diet itself has been simultaneously analyzed. The thirty urines represented by Tables I–VII were obtained from six different normal persons, all kept for seven days on one standard uniform diet; and in order that all the urines should fairly represent the diet, the first two twenty-four-hour quantities were discarded and only the last five were analyzed.

TABLE I—MR. J. H. B.

Weight in kilos. / Date. Sept.	Sp. gr. 1.0— / Volume of urine. c.c.	Total nitrogen. N_2.	Urea. gm. / Urea-N.	Ammonia c.c. $\frac{n}{10}NH_3$. / Ammonia-N.	Kreatinin. gm. / Kreatinin-N.	Uric acid. gm. / Uric acid-N.	Undetermined nitrogen. gm.	In per cent of Total Nitrogen.					
								Urea.	Ammonia.	Urea + ammonia.	Kreatinin.	Uric acid.	Undetermined N_2.
57.4 7	*17* 1980	16.8	*28.9* 13.5	*649.0* 0.91	*1.54* 0.57	*0.33* 0.11	0.71	86.3	5.4	91.7	3.4	0.7	4.2
8	*19* 1840	16.9	*31.7* 14.8	*684.0* 0.96	*1.47* 0.55	*0.29* 0.10	0.49	87.6	5.7	93.3	3.2	0.6	2.9
9	*20* 1655	17.2	*32.5* 15.2	*583.0* 0.82	*1.60* 0.58	*0.36* 0.12	0.46	88.2	4.8	93.0	3.9	0.7	2.4
10	*17* 1770	16.3	*30.6* 14.3	*580.0* 0.81	*1.56* 0.58	*0.34* 0.11	0.50	87.7	5.0	92.7	3.6	0.7	3.0
57.4 11	*16* 1815	15.9	*29.8* 13.9	*546.0* 0.76	*1.70* 0.63	*0.34* 0.11	0.50	87.5	4.8	92.3	4.0	0.7	3.0
Average	1812	16.6	*30.6* 14.3	*608.0* 0.85	*1.57* 0.59	*0.33* 0.11	0.53	87.5	5.1	92.6	3.6	0.7	3.1

TABLE II—MR. E. H. S.

67.0 29	*27* 1120	13.9	*25.9* 12.1	*493.0* 0.69	*1.41* 0.53	*0.19* 0.06	0.53	87.0	4.9	91.9	3.8	0.5	3.8
30	*18* 1740	15.4	*28.7* 13.4	*543.0* 0.76	*1.50* 0.56	*0.26* 0.09	0.75	87.1	4.8	91.9	3.6	0.6	4.9
1	*22* 1260	14.5	*26.7* 12.5	*486.0* 0.68	*1.49* 0.55	*0.20* 0.07	0.70	85.8	4.7	90.5	3.8	0.5	5.2
2	*29* 900	14.3	*25.8* 12.1	*475.0* 0.67	*1.44* 0.54	*0.22* 0.07	0.92	84.5	4.7	89.2	3.8	0.6	6.4
66.1 3	*32* 960	15.9	*29.7* 13.9	*465.0* 0.65	*1.42* 0.53	*0.33* 0.11	0.73	87.3	4.1	91.4	3.3	0.7	4.6
Average	1196	14.8	*27.3* 12.8	*492.0* 0.69	*1.46* 0.54	*0.24* 0.08	0.72	86.2	4.6	90.8	3.6	0.6	5.0

TABLE I — *Continued.*

Date.	Total sulphur as SO_3. "S."	Inorganic SO_3. "S_1."	Ethereal SO_3. "S_2."	"Neutral" S_3. "S_3."	In per cent of Total Sulphur. S_1.	S_2.	S_3.	Acidity in c.c. $\frac{n}{10}$. Total, titrated.	Mineral.	Organic.	Total phosphates as P_2O_5.	Chlorine. gm.	Indican (Fehling's solution = 100).	Remarks.
7	3.40	3.04	0.18	0.18	89.4	5.3	5.3	515	..	..	3.62	7.3	10	
8	3.56	3.19	0.20	0.17	89.6	5.6	4.8	574	140	434	3.73	6.5	70	
9	3.40	3.06	0.19	0.15	90.0	5.6	4.4	550	298	252	3.57	6.1	85	
10	3.42	3.00	0.19	0.23	87.7	5.5	6.8	580	205	375	3.79	5.7	80	
11	3.27	3.00	0.18	0.09	91.7	5.5	2.8	552	174	378	3.76	5.8	12	
Av'ge	3.41	3.06	0.19	0.17	89.6	5.5	5.0	554	204	360	3.69	6.3	51	

TABLE II — *Continued.*

29	3.08	2.64	0.23	0.21	85.7	7.4	7.0	605	398	207	3.61	6.8	90	
30	3.09	2.62	0.25	0.22	84.8	8.1	7.1	668	403	265	3.86	6.5	90	
1	3.08	2.64	0.24	0.20	85.7	7.3	7.0	680	378	302	3.74	5.3	90	
2	3.09	2.65	0.27	0.17	85.7	8.7	5.5	698	435	265	3.84	5.1	80	
3	3.22	2.83	0.29	0.10	87.9	9.0	3.1	695	472	223	4.06	5.9	80	
Av'ge	3.11	2.67	0.25	0.19	85.8	8.0	6.1	669	417	252	3.82	5.9	85	

TABLE III—MR. R. L. J.

Weight in kilos. / Date. Sept.	Sp. gr. 1.0—. / Volume of urine. c.c.	Total nitrogen. N_2.	Urea. gm. / Urea-N.	Ammonia. c.c. $\frac{n}{10}$ NH_3. / Ammonia-N.	Kreatinin. gm. / Kreatinin-N.	Uric acid. gm. / Uric acid-N.	Undetermined nitrogen. gm.	In per cent of Total Nitrogen.					
								Urea.	Ammonia.	Urea + ammonia.	Kreatinin.	Uric acid.	Undetermined N_2.
70.8 / 21	*19* / 1520	15.9	*29.3* / 13.7	*466.0* / 0.64	*1.64* / 0.61	*0.24* / 0.08	0 81	85.9	4.1	90.0	3.8	0.5	5.7
22	*21* / 1530	16.6	*31.0* / 14.5	*514.0* / 0.72	*1.56* / 0.58	*0.30* / 0.10	0.80	86.9	4.3	91.2	3.6	0.6	4.6
23	*22* / 1460	16.6	*30.6* / 14.4	*520.0* / 0.73	*1.53* / 0.56	*0.33* / 0.11	0.83	86.5	4.4	90.9	3.4	0.7	5.0
24	*24* / 1430	16.5	*30.4* / 14.2	*532.0* / 0.75	*1.67* / 0.52	*0.37* / 0.12	0.90	86.1	4.5	90.6	3.2	0.7	5.5
70.1 / 25	*23* / 1380	16.6	*30.7* / 14.5	*618.0* / 0.86	*1.45* / 0.54	*0.33* / 0.11	0.85	85.7	5.2	90.9	3.3	0.7	5.1
Av'ge	1444	16.4	*30.3* / 14.1	*520.0* / 0.74	*1.57* / 0.59	*0.31* / 0.10	0.85	86.2	4.5	90.7	3.5	0.6	5.3

TABLE IV—MR. G. E. C.

70.9 / 31	*18* / 1740	16.2	*30.6* / 14.3	*571.0* / 0.80	*1.88* / 0.70	*0.42* / 0.14	0.30	87.9	4.9	92.8	4.3	0.9	2.0
Aug.-Sept. 1	*24* / 1220	15.0	*28.0* / 13.1	*542.0* / 0.76	*1.74* / 0.65	*0.41* / 0.14	0.48	86.6	5.0	91.6	4.3	0.9	3.2
2	*26* / 1010	13.9	*25.8* / 12.0	*485.0* / 0.68	*1.67* / 0.62	*0.36* / 0.12	0.41	86.7	4.9	91.6	4.5	0.9	3.0
3	*20* / 1330	14.8	*27 4* / 12.8	*606.0* / 0.85	*1.72* / 0.64	*0.36* / 0.12	0.39	87.0	4.7	91.7	4.3	0.8	3.1
71.1 / 4	*20* / 910	14.0	*25.8* / 12.0	*539.0* / 0.75	*1.82* / 0.68	*0.62* / 0.21	0.36	85.4	5.4	90.9	4.9	1.5	2.7
Av'ge	1242	14.8	*27.4* / 12.8	*549.0* / 0.77	*1.77* / 0.66	*0.44* / 0.15	0.41	86.7	5.0	91.7	4.5	1.0	2.8

TABLE III — *Continued.*

Date.	Total sulphur as SO_3. "S."	Inorganic SO_3. "S_1."	Ethereal SO_3. "S_2."	"Neutral" SO_3. "S_3."	In per cent of Total Sulphur.			Acidity in c.c. $\frac{n}{10}$.			Total phosphates as P_2O_5.	Chlorine. gm.	Indican (Fehling's solution = 100).	Remarks.
					S_1.	S_2.	S_3.	Total, titrated.	Mineral.	Organic.				
21	3.31	2.85	0.25	0.21	86.1	7.6	6.3	589	219	370	3.98	6.3	140	
22	..	3.00	0.25	..	..	..	..	630	299	331	4.16	5.7	150	
23	3.35	2.89	0.28	0.18	86.3	8.3	5.4	625	432	193	3.84	5.8	140	
24	3.20	2.73	0.24	0.13	85.3	7.5	4.1	617	..	..	3.68	5.7	140	
25	3.25	2.92	0.21	0.12	89.8	6.5	3.7	646	276	370	3.85	5.2	130	
Av'ge	3.28	2.88	0.25	0.16	84.7	7.6	4.8	621	308	313	3.90	5.7	140	

TABLE IV — *Continued.*

31	3.22	2.87	0.24	0.11	89.1	7.4	3.4	619	257	362	4.09	6.8	14	
1	3.10	2.76	0.22	0.12	89.0	7.1	3.9	697	410	287	4.10	5.8	85	
2	..	2.67	0.17	..	..	..	..	638	412	226	3.86	5.2	85	
3	3.00	2.69	0.17	0.14	89.7	5.7	4.6	648	388	260	3.94	5.5	80	
4	3.11	2.80	0.18	0.13	90.0	5.8	4.2	691	408	283	3.82	4.6	87	
Av'ge	3.11	2.76	0.19	0.13	89.4	6.5	4.1	601	375	284	3.96	5.6	70	

TABLE V — MR. M. H.

Weight in kilos.	Sp. gr. 1.0—.	Total nitrogen. N_2.	Urea. gm.	Ammonia. c.c. $\frac{N}{10}$ NH_3.	Kreatinin. gm.	Uric acid. gm.	Undetermined nitrogen. gm.	In per cent of Total Nitrogen.					
Date. Aug.	Volume of urine. c.c.		Urea-N.	Ammonia-N.	Kreatinin-N.	Uric acid-N.		Urea.	Ammonia.	Urea + ammonia.	Kreatinin.	Uric acid	Undetermined N_2.
56.6 24	*18* 1040	14.4	*27.6* 12.9	*362.0* 0.51	*1.31* 0.50	*0.48* 0.16	0.37	89.3	3.4	92.7	3.5	1.1	2.9
25	*20* 1590	16.4	*31.5* 14.7	*470.0* 0.66	*1.38* 0.51	*0.52* 0.17	0.31	90.0	4.0	94.0	3.7	1.0	2.0
26	*145* 2000	13.9	*26.5* 12.4	*352.0* 0.49	*1.22* 0.45	*0.35* 0.12	0.46	89.1	3.6	92.7	3.3	0.9	3.3
27	*19* 1695	15.2	*28.9* 13.5	*392.0* 0.55	*1.38* 0.51	*0.47* 0.16	0.43	89.4	3.6	93.0	3.3	1.0	2.8
56.5 28	*175* 1930	15.8	*30.2* 14.1	*386.0* 0.53	*1.50* 0.56	*0.50* 0.17	0.46	89.1	3.4	92.5	3.5	1.1	2.9
Average	1645	15.1	*28.9* 13.5	*392.0* 0.55	*1.36* 0.50	*0.46* 0.15	0.41	89.4	3.6	93.0	3.3	1.0	2.7

TABLE VI — MR. S. R. B.

57.8 13 Sept.	*285* 1065	16.6	*31.3* 14.6	*428.0* 0.60	*1.53* 0.57	*0.44* 0.15	0.67	88.1	3.6	91.7	3.4	0.9	4.0
14	*275* 1230	19.5	*36.9* 17.2	*443.0* 0.62	*1.60* 0.60	*0.45* 0.15	0.90	88.3	3.2	91.5	3.1	0.8	4.6
15	*255* 1290	18.0	*34.7* 16.2	*345.0* 0.48	*1.55* 0.58	*0.48* 0.16	0.56	90.1	2.7	92.8	3.2	0.9	3.1
16	*28* 1240	19.4	*37.1* 17.3	*511.0* 0.72	*1.64* 0.61	*0.46* 0.15	0.62	89.3	3.5	92.8	3.1	0 8	3.3
58.2 17	*27* 1370	17.7	*33.9* 15.8	*438.0* 0.61	*1.60* 0.60	*0.40* 0.13	0.56	89.4	3.4	92.8	3.3	0.8	3.1
Average	1239	18.2	*34.7* 16.2	*433.0* 0.60	*1.58* 0.59	*0.44* 0.15	0.66	89.0	3.3	92.3	3.2	0.8	3.7

TABLE V — *Continued.*

Date.	Total sulphur as SO_3. "S."	Inorganic SO_3. "S_1."	Ethereal SO_3. "S_2."	"Neutral" SO_3. "S_3."	In per cent of Total Sulphur.			Acidity in c.c. $\frac{n}{10}$.			Total phosphates as P_2O_5.	Chlorine. gm.	Indican (Fehling's solution = 100).	Remarks.
					S_1.	S_2.	S_3.	Total, titrated.	Mineral.	Organic.				
24	2.98	2.74	0.16	0.08	91.9	5.4	2.7	499	120	379	2.95	6.8	25	
25	3.31	2.95	0 23	0.13	89.1	7.2	3.7	686	311	375	3.78	7.1	20	
26	2.83	2.51	0.19	0.13	88.7	6.7	4.5	552	316	236	3.26	6.5	3	
27	3.46	3.15	0.20	0.11	91.0	5.8	3.2	613	226	387	3.73	7.1	10	
28	3.65	3.14	0.17	0.34	86.0	4.6	9.4	672	255	417	3.76	7.0	3	
Av'ge.	3.25	2.90	0.19	0.16	89.2	5.8	5.0	604	247	359	3.44	6.9	12	

TABLE VI — *Continued.*

13	3.77	3.38	0.18	0.21	89.6	4.8	5.6	618	264	354	4.07	5.3	95	
14	3.74	3.30	0.26	0.18	88.2	7.0	4.8	674	310	364	4.37	6.1	100	
15	3.63	3.15	0.29	0.19	86.8	8.0	5.2	542	150	392	4.39	6.6	110	
16	..	3.55	0.39	..	..	..	..	768	367	401	5.01	5.5	110	
17	3.80	3.19	0.33	0.28	84.0	8.7	7.3	652	..	..	4.66	7.0	110	
Av'ge.	3.73	3.25	0.25	0.19	87.2	7.2	5.5	651	273	378	4.50	6.1	105	

TABLE VII.

AVERAGES OF TABLES I–VI.

Initial weight, kilos. / Table No.	Volume of urine, c.c.	Total nitrogen, N_2.	Urea. gm. / Urea-N.	Ammonia. c.c. $\frac{n}{10}$ NH_3. / Ammonia-N.	Kreatinin. gm. / Kreatinin-N.	Uric acid. gm. / Uric acid-N.	Undetermined nitrogen.	In per cent of Total Nitrogen.					
								Urea.	Ammonia.	Urea + Ammonia.	Kreatinin.	Uric acid.	Undetermined N_2.
57.4 1	1812	16.6	*30.6* 14.3	*608* 0.85	*1.57* 0.59	*0.33* 0.11	0.53	87.5	4.1	92.60	3.6	0.7	3.10
67.0 2	1196	14.8	*27.3* 12.8	*492* 0.69	*1.46* 0.54	*0.24* 0.08	0.72	86.2	4.6	90.80	3.6	0.6	5.00
70.8 3	1444	16.4	*30.3* 14.1	*529* 0.74	*1.57* 0.59	*0.31* 0.10	0.85	86.2	4.5	90.70	3.5	0.6	5.30
70.9 4	1242	14.8	*27.4* 12.8	*549* 0.77	*1.77* 0.66	*0.44* 0.15	0.41	86.7	5.0	91.70	4.5	1.0	2.80
56.6 5	1645	15.1	*28.9* 13.5	*392* 0.55	*1.36* 0.50	*0.46* 0.15	0.41	89.4	3.6	93.00	3.3	1.0	2.70
57.8 6	1239	18.2	*34.7* 16.2	*433* 0.60	*1.58* 0.59	*0.44* 0.15	0.66	89.0	3.3	92.30	3.2	0.8	3.70
Final average.	1430	16.0	*29.8* 13.9	*500* 0.70	*1.55* 0.58	*0.37* 0.12	0.60	87.5	4.3	91.85	3.6	0.8	3.75
Minimum	1196	14.8	*27.3* 12.8	*392* 0.55	*1.36* 0.50	*0.24* 0.08	0.41	86.2	3 3	90.70	3.2	0.6	2.70
Maximum	1812	18.2	*34.7* 16.2	*608* 0.85	*1.77* 0.66	*0.46* 0.15	0.85	89.4	5.0	92.60	4.5	1.0	5.30

TABLE VII — *Continued.*

Table No.	Total sulphur as SO_3. "S."	Inorganic SO_3. "S_1."	Ethereal SO_3. "S_2."	"Neutral" SO_3. "S_3."	In per cent of Total Sulphur.			Acidity in c.c. $\frac{n}{10}$.			Total phosphates as P_2O_5.	Chlorine. gm.	Indican (Fehling's solution = 100).	Remarks. Wt.
					S_1.	S_2.	S_3.	Total, titrated.	Mineral.	Organic.				
1	3.41	3.06	0.19	0.17	89.6	5.5	5.0	554	204	360	3.69	6.3	51	
2	3.11	2.67	0.25	0.19	85.8	8.0	6.1	669	417	252	3.82	5.9	85	
3	3.28	2.88	0.25	0.16	84.7	7.6	4.8	621	308	313	3.90	5.7	140	
4	3.11	2.76	0.19	0.13	89.4	6.5	4.1	601	375	284	3.96	5.6	70	
5	3.25	2.90	0.19	0.16	89.2	5.8	5.0	604	247	359	3.44	6.9	12	
6	3.73	3.25	0.25	0.19	87.2	7.2	5.5	651	273	378	4.50	6.1	105	
														kilos.
Av'ge	3.31	2.92	0.22	0.17	87.8	6.8	5.1	617	304	313	3.87	6.1	77	63.4
Min.	3.11	2.67	0.19	0.13	84.7	5.5	4.1	554	204	252	3.44	5.6	12	56.6
Max.	3.73	3.25	0.25	0.19	89.6	8.0	6.1	669	417	378	4.50	6.9	140	70.9

The diet which these urines represent was made up as follows:

Whole milk	500 c.c.
Cream (18–22 per cent fat)	300 c.c.
Eggs (white and yolk)	450 gm.
Horlick's Malted Milk	200 gm.
Sugar	20 gm.
Sodium chloride	6 gm.

Water enough to make the whole up to two litres.
Extra water to drink 900 c.c.

The ingredients combined into a liquid mixture contained 119 gm. protein and approximately 148 gm. fat and 225 gm. carbohydrates. The following determinations made at different times show that the mixture as prepared had a very constant composition:

Cl_2	SO_3	P_2O_5	N_2
6.25	3.69	5.75	18.92
6.02	3.71	5.54	18.80
	3.62	5.92	18.86
	3.81	5.92	18.86
	3.80		19.05
	3.84		19.05
			19.02
			19.02
			19.02

The above diet fulfils sufficiently well the requirements of the so-called dietary standards, considering the class of persons for whom it was originally intended (patients in a private hospital for the insane). In regard to the protein, it corresponds almost exactly with the value demanded by Voit for a man weighing 70 kgm.; and since four out of the six normal persons experimented upon weighed less than 70 kgm. and the other two weighed no more than 70 kgm., the diet may be said to be liberal rather than too scanty with respect to its protein-content.

It is not my intention to devote any space to a discussion of these thirty normal urines, for the very reason that they correspond so closely to what we have been accustomed to consider normal.

A number of points could profitably be touched upon on the basis of these tables, as, for example, the quantitative relation between ethereal sulphates, neutral sulphur, and indican; between ammonia,

total nitrogen, and the acidities; between chlorides, total nitrogen, and the volume of urine. These and several other more important points can, however, be considered to better advantage on the basis of the experimental material given in the next paper. In order to avoid unnecessary repetitions they may therefore be passed over here. The importance of Tables I–VII lies in the fact that they constitute concrete examples representing the prevailing views concerning the composition of normal human urine.