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THE PROTEIN METABOLISM OF AN INFANT*

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The diversity of opinion among pediatricians concerning the digestion of protein has led to much discussion, and although certain phases of the question have been cleared up, there still remains much to explain. Recently Mendel and his co-workers have attacked the problem from a new angle in their brilliant studies in growth and the part played by the various members of the protein group in affording a "growth impulse" in growing animals. Studies of the effect of protein on the energy metabolism of infants have been carried on in Professor Lusk's laboratories at Cornell University Medical College by Howland¹ and more recently Hoobler and Murlin² have added much to our knowledge of this phase of the subject.

Although clinical symptoms of protein indigestion have been recognized by many clinicians, mainly of the American schools, an equally large number maintain that protein is harmless even in large amounts. The two groups may be roughly divided into those who use raw milk in infant feeding on the one hand, and those who use principally boiled or heated milk on the other hand. The question of the age of the infant also plays a part in the quantity of protein that may be given without resulting in symptoms of indigestion. It may be said, in general, the younger the infant is, the more frequently do symptoms of indigestion appear when large doses of protein are given. After the age of 5 or 6 months, the danger of giving an average infant more protein than it can tolerate diminishes rapidly. Exceptions, however, may be found in the abnormally strong and vigorous infant who can digest more, or the weak infant who can digest relatively less, at a given age. A third factor which seems to influence the ability of the infant to digest protein is presence of disease in the intestines. That

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1. Howland: Tr. Fifteenth Internat. Cong. Hyg. and Demog., 1912, ii, 438.

2. Murlin and Hoobler: *AM. JOUR. DIS. CHILD.*, 1915, ix, 81. Hoobler: *AM. JOUR. DIS. CHILD.*, 1915, x, 153.

is not confined to protein alone, but applies to all the other food elements. Finally, clinical symptoms of indigestion which apparently are the result of too much protein in the food are not so common as those which are brought about by an excess of carbohydrates or fat in the food. These symptoms depend in part on whether the milk is raw or sterilized. Since the only definite outward signs of protein indigestion are casein curds in the stools, and since boiling the milk causes these curds to disappear from the stools,³ casein curds are rarely seen in communities which sterilize all their milk, and the diagnosis of protein indigestion is made more difficult than ever.

Selter⁴ described a picture of intoxication from protein in which there was an excursion of body temperature from 37 C. (98.6 F.) to 34 C. (93.2 F.) (subnormal), slow pulse and superficial respiration. The color of the skin became bluish gray. He found that the urine contained a kenotoxin which, when injected into mice, resulted in symptoms similar to those which he described in babies. Hoobler⁵ subsequently found that when a large amount of protein was given to an infant, "the child no longer took interest in his surroundings, and gradually entered into a state of semistupor. The pulse was slower and there were times when the respirations were slightly irregular. The stupor continued for a few days after the observations ceased," after which "it gradually lessened, so that within one week the child was normal again and began to gain weight." Monrad⁶ and Morse⁷ believe that casein is not harmless and may cause indigestion, while Salge⁸ speaks of a condition in which he is unable to give specific clinical symptoms, as *Eiweissnährschaden*. Holt and Levene⁹ observed a rise in temperature in five instances during the administration of a "synthetic food" containing 6 per cent. of casein, and a retention of chlorids for three or four days preceding the rise in temperature. They draw attention to the similar rise in temperature described by Vaughan after the parenteral injection of protein. Finkelstein and his followers, on the other hand, believe that casein is harmless, while Howland¹⁰ and others say that casein curds in the stools are of "limited, if any, pathological importance, but rather depend on physical conditions in the gastro-intestinal tract."

3. Brenneman: AM. JOUR. DIS. CHILD., 1911, i, 341. Ibrahim: Monatschr. f. Kinderh., 1911, x, 55.

4. Selter: Deutsch. med. Wchnschr., 1908, p. 512.

5. Hoobler: Footnote 2, second reference.

6. Monrad: Monatschr. f. Kinderh., 1911, x, 244.

7. Morse: New York Med. Jour., 1913, xcvi, 477.

8. Salge: Ztschr. f. Kinderh., 1912, 112.

9. Holt and Levene: Med. Klin., 1913, ix, 258.

10. Howland: AM. JOUR. DIS. CHILD., 1913, v, 390.

An analysis of the figures of previous investigators does not give any explanation of the clinical symptoms which are seen in practice, and it was with the hope of answering some of the clinical questions that this investigation was undertaken. Although the figures obtained do not answer any questions from the point of view of the clinician, they contain many interesting facts which will be commented on later, and serve to substantiate or amplify the findings of previous investigators. We believe that they are of sufficient importance to record.

F. W. L. was born Dec. 4, 1913, at full term. During the first three months of life he was fed on modified milk. On March 12, 1914, he came to the outpatient department of the Massachusetts General Hospital with colic and

Fig. 1.—Metabolism record of F. W. L., covering a period of nearly two months, showing the intake of fat, protein and sugar from day to day, its value in calories per kilogram of body weight, the increase in weight of the infant and the variation in body temperature.

constipation, and weighing 4,280 gm. His formula was changed from time to time, the last one being fat 2.5, lactose 6, protein 1.6, 4 ounces, 7 feedings. Just before entering the children's ward, April 23, 1914, at the age of 4½ months, he weighed 4,315 gm. Physical examination showed that he was poorly developed and poorly nourished with flabby musculature, but was otherwise normal, the only fact worthy of note being that the liver dullness extended from the fourth intercostal space to 3 cm. below the edge of the ribs in the nipple line. Figure 1 shows the temperature, weight curves, calories and food per twenty-four hours, given during the time he was in the hospital, and at the different periods investigated. The periods in which the food and excreta were examined were each of three days' duration, the stools at the beginning and end of each period were marked off with charcoal. In one instance the food was changed twenty-four hours before the period commenced, and

in all others several days had elapsed after the food was changed and before the period was commenced. The urine and stools were collected in the manner described by one of us,¹¹ and it was frequently noted that the baby was perfectly comfortable during the periods of investigation. Figure 1 shows that during the entire period the baby was in the hospital he gained from 4,280 gm., his weight on entrance, to 5,275 gm., his weight on discharge, June 16.

The periods were arranged so far as possible so that he would receive the same number of calories per kilogram of body weight per day. The amount of protein was increased in each successive period so that during the last period he was offered over three times as much as he had during the first period. During the last period the baby refused to take all the food offered him, thus reducing the protein intake. The milk used in mixing the formulas was raw. The writers believe that boiling the milk might have modified the results obtained.

TABLE 1.—TOTAL FIGURES FOR EACH THREE-DAY—

Period	Age, Mo.	Weight		Food							Urine	
		Start, Kg.	End, Kg.	Calo-ries per 24 Hr.	Calo-ries per Kg.	Fat, Gm.	Sugar, Gm.	Pro-tein, Gm.	Nitro-gen, Gm.	Ash, Gm.	Nitro-gen, Gm.	Ash, Gm.
1	5¼	4.3	4.335	527	122	106	143	31	4.79	9.26	2.876	2.37
2	5½	4.415	4.65	650	143	107	196	60	9.31	11.33	5.816	5.02
3	6	4.66	4.936	626	130	102	176	70	11.06	18.3	7.482	6.69
4	6½	4.98	5.17	649	130	84	217	89	13.91	21.6	8.065	7.4
5	6¾	5.05	5.235	628	123	64	233	109	17.01	27.66	11.893	13.87

Table 1 shows the total amount of calories, fat, sugar, protein, nitrogen and ash ingested for each period of three days, and the amount excreted in the urine and stools.

It was found that in Period 1 the baby was hungry, even though he was receiving 122 calories per kilogram of body weight. The investigations of Benedict and Talbot¹² have shown that the more a baby is underweight the greater will its basal heat production be per kilogram of body weight per twenty-four hours. It is not surprising then that it was necessary to give the baby more than 120 calories because he weighed less than the average weight for his age (4,300 gm. against the average weight of 6,800 gm.). The amount of food, therefore, was increased until the baby was satisfied in the second period. From this time on he received approximately the same total number of

11. Talbot: Apparatus for Metabolism Experiments in Male Infants, Jour. Am. Med. Assn., 1909, liii, 1818.

12. Morse and Talbot: Discussion of Benedict and Talbot, Dis. Nutrition and Infant Feeding, New York, 1915, p. 56.

calories in twenty-four hours. The calories per kilogram of body weight gradually fell as his weight increased, and it was necessary to vary the fat and sugar (lactose) in order to compensate for the increasing amount of protein given. Since the ash is principally in the protein of the milk, the ash increased as the protein increased.

Folin's¹³ investigations on the adult showed that if a man ingested a diet containing a medium amount of protein, and again one nearly free from protein, the difference in amount of total nitrogen in the urine in the two instances was due almost exclusively to a difference in the output of urea. The quantity of creatinin eliminated remains independent of the quantity of protein metabolized, provided the diet is practically creatin free, as Folin's were, the protein being supplied from milk. The same is less strikingly true of uric acid. This led Folin to distinguish between an endogenous, or repair, protein metabol-

—PERIOD; DETAILED ANALYSIS OF URINE NOT INCLUDED

Nitro- gen,	Ash, Gm.	Total Fat, Gm.	Stool					Nitro- gen Bal- ance, Gm.	Fat Util- ized, per Cent.	Ash Bal- ance, Gm.	Weight Bal- ance, Gm.
			Neut- ral Fat, Gm.	Fatty Acids and Soaps, Gm.	NH ₃ Nitro- gen, Gm.	NH ₃ Nitro. in % Total N	Titra- ble Acid, Gm.				
0.895	4.21	19.16	0	19.16	0.087	9.7	51	1.02+	82	2.68+	35+
1.28	7.4	12.1	0.32	11.78	0.16	12.5	82	2.21+	89	1.09—	285+
1.475	7.84	8.42	0	8.52	0.12	8.1	42	2.10+	91	2.76+	276+
1.92	8.53	14.9	1.34	18.56	0.183	6.4	96	3.92+	88	5.67+	240+
3.477	12.08	12.37	1.03	11.34	0.254	7.3	194	1.64+	81	1.71+	180+

ism, and an exogenous, or energy, protein metabolism. That is, the term "endogenous" metabolism is used for the chemical processes which are concerned in maintaining the chemical structure of the cell protoplasm, in contrast to the processes of combustion, which the cell carries on for the purpose of using the resulting energy in accomplishing its physiologic functions. Creatinin and uric acid are regarded as being produced solely by endogenous metabolism. Probably some ammonia and urea are also produced by the processes of repair metabolism, but in the main ammonia and urea together represent the extent of the combustion of protein, for the sake of its energy content, and will depend on the amount left over after the cell protoplasm has supplied its structural needs. The absolute amount of ammonia appearing in the urine, is, as shown by Henderson and Palmer,¹⁴ a measure of the extent to which this organic base is being used to maintain the nor-

13. Folin: *Am. Jour. Physiol.*, 1905, xiii, 117.

14. Henderson and Palmer: *Jour. Biol. Chem.*, 1914, xvii, 305.

mal reaction of the blood. The ammonia is available for this purpose at the expense of the neutral substance, urea.

If Folin's views are accepted, we may expect that since the process of cell repair probably goes on at a fairly constant pace in a normal

TABLE 2.—DAY TO DAY DETERMINATIONS FOR ACID FACTORS, NITROGEN—
THREE-DAY PERIODS WITH—

Period	Protein in Food, Gm.	24-Hour Amount Urine, C.c.	Acid Excretion					Nitrogen, Mg.		
			+ (H)	Titra- ble Acid, C.c., N/10	NH ₃ C.c., N/10	Total Acid, C.c., N/10	A/NH ₃	Total Nitro- gen	Urea N	NH ₃ N
1	10.5	720	5.9	54	127	181	0.43	966	669	178
	9.9	815	5.3	84	170	254	0.5	966	624	238
	10.2	750	6	60	121	181	0.5	944	688	170
2	20.7	740	5.9	57	114	171	0.5	2,062	1,717	159
	19.1	775	6.4	55	116	171	0.47	1,842	1,614	163
	19.5	900	5.9	52	105	157	0.5	1,912	1,548	147
3	24.5	840	6.7	48	107	155	0.45	2,632	2,234	148
	24.6	760	6.7	48	131	179	0.37	2,470	2,039	183
	21.3	740	6.2	63	139	202	0.45	2,380	1,944	194
4	29.1	600	...	..	...	...	....	2,205	.....	...
	28.1	790	...	..	...	...	....	3,000	.....	...
	31.4	805	...	..	...	...	....	2,860	.....	...
5	35.8	850	...	..	...	...	....	3,871	.....	...
	35.3	700	...	..	...	...	....	3,942	.....	...
	37.4	900	...	..	...	...	....	4,080	.....	...

TABLE 3.—SUMMARY FROM TABLE 2; FIGURES ARE FOR—
RESULTS FOR THE THREE—

Period	Protein in Food, Gm.	Amount Urine, C.c.	Acid Excretion					Nitrogen, Mg.		
			+ (H)	Titra- ble Acid, C.c., N/10	NH ₃ C.c., N/10	Total Acid, C.c., N/10	A/NH ₃	Total Nitro- gen	Urea N	NH ₃ N
1	10.2	762	5.8	66	139	205	0.47	959	660	195
2	20.0	805	6.1	55	112	166	0.49	1,939	1,626	156
3	23.3	780	6.5	53	126	179	0.42	2,494	2,072	175
4	29.5	732	...	..	...	...	....	2,688	.....	...
5	36.2	817	...	..	...	...	....	3,964	.....	...

individual, the end products of endogenous metabolism will be constant in the absolute amount and unaffected by the varying amount of protein in the diet, whereas, the total urea plus ammonia nitrogen will vary directly with the protein intake. As there is no known organ in

the body in which protein is stored, the surplus protein (after cell repair and growth in infants have been supplied) must be burned.

Table 1 shows the total figures for each three-day period. During each period the baby gained rapidly in weight with the exception of

—AND SULPHUR PARTITION, PHOSPHATES AND CHLORIDS IN URINE FOR FIVE
—INCREASING PROTEIN INTAKE

Nitrogen, Mg.					Sulphur, Mg. SO ₃				Phos- phates, Mg. P ₂ O ₅	Chlorids, Mg.
Creat- inin N	Crea- tin N	Uric Acid N	Un- deter- mined N	Per Cent. of Food N in Urine	Total	Inor- ganic	Eth- ereal	Neut- ral		
25	1	32	61	59	174	95	29	50	360	350
25	3	31	41	62	200	121	..	44	540	770
19	4	33	30	59	202	118	26	58	500	90
20	13	11	150	64	363	269	14	81	520	520
19	11	10	25	61	338	246	18	73	550	570
20	11	13	173	62	317	239	12	67	420	560
22	28	19	181	64	429	362	14	54	550	600
21	29	17	181	59	433	361	16	57	540	830
22	22	17	191	66	420	366	10	45	600	1,130
20	25	..	...	48	385	318	13	54	660	690
22	28	..	...	68	509	423	17	69	730	1,680
20	22	..	...	58	501	421	15	65	720	1,340
25	39	..	...	69	672	594	12	65	940	1,800
22	40	..	...	71	679	588	20	71	920	1,800
23	39	..	...	70	680	595	22	70	950	1,800

—TWENTY-FOUR HOUR AMOUNTS OBTAINED BY AVERAGING THE
—SUCCESSIVE DAYS OF EACH PERIOD

Nitrogen, Mg.				Sulphur, Mg. SO ₃				Phos- phates, Mg. P ₂ O ₅	Chlorids, Mg.
Creat- inin N	Crea- tin N	Uric Acid N	Un- deter- mined N	Total	Inor- ganic	Eth- ereal	Neutral		
23	3	32	44	190	111	28	51	467	403
20	13	11	116	344	255	15	74	497	550
22	26	18	184	428	363	13	52	563	853
21	25	..	...	465	387	15	63	708	1,237
23	39	..	...	679	592	18	69	937	1,800

Period 1, in which he received the minimum amount of protein and fewer calories than during any other period. He was hungry after each feeding, and, therefore, the amount of food was increased until he was satisfied. During the remaining periods he was satisfied and

happy. The increase of nitrogen in the food was accompanied by a regular increase of the total nitrogen in the urine. This corresponds with the findings both in the infant and in the adult. There was an increase of ash in both the urine and the stools as the protein or nitrogen in the food was increased, and there was more ash in the stool than in the urine in all periods except Period 5, in which slightly more was excreted through the urinary tract than through the gastro-intestinal tract. The increasing amount of ash in the food did not affect its mode of exit from the body. There was, however, a marked increase in the titrable acidity of the stools in the last period, and a larger amount of sugar in the food during this period, which may have had some causative relation to these findings.

TABLE 4.—AMOUNT OF ETHEREAL SULPHATES IN URINE WITH AN INCREASING AMOUNT OF AMMONIA IN THE STOOL; FIGURES ARE FOR TWENTY-FOUR-HOUR AMOUNTS

Period	Protein per Kg. in Food, Gm.	NH ₃ N in Stool, Gm.	Total Sulphur in Urine, Mg. SO ₃	Ethereal Sulphates, Mg. SO ₃		
				Total	Per Kg.	Percentage Total Sulphur
1	2.3	29	190	28	6.5	14.7
2	4.4	53	344	15	3.3	4.4
3	4.8	40	428	13	2.7	3
4	5.9	61	465	15	3.0	3.2
5	7.1	85	679	18	3.6	2.6

The retention of nitrogen (nitrogen balance) increased with the increase of nitrogen in the food up to the last period, when the baby refused to take all the food that was offered him, and, clinically, seemed to be on the verge of a digestive upset. In this period there was a marked diminution of the retention of nitrogen and a great increase in the nitrogen in the stools. During the last two periods there were casein curds in the stools, a very few in the fourth period, when there was a slight increase in the stool nitrogen, and many in the fifth period, when there was a great increase in the stool nitrogen. In the latter instance they made up 15 per cent. of the total fecal nitrogen.¹⁵ Coincidentally there was a decrease in the retention of ash. (We are unable to explain the negative ash balance in Period 2.) These figures make one speculate as to what might have happened if a further increase of protein had been persisted in. The

15. The stools during the other periods were remarkably uniform in quality. They were light yellow or yellow, of smooth salve-like consistency, never stiff. They were normal in all respects except that they were quite a bit larger than the usual twenty-four hour stool.

figures of the utilization of fat do not indicate that the fat digestion was influenced to any great degree by the changes made in the food.

Table 2 shows the day to day determinations for acid factors, nitrogen and sulphur partition, phosphates and chlorids in the urine for each of the five three-day periods.

Table 3, which is a summary of Table 2, shows that the amount of ammonia excreted in the urine is closely in proportion to the titrable acid in the urine. Henderson and Palmer¹⁴ find in adults with normal kidneys that titrable acidity divided by the ammonia gives a fairly constant ratio of 0.75 in average, regardless of the amount of protein in the diet. The ratio titrable acidity divided by the ammonia in our

TABLE 5.—CREATININ, URIC ACID, ETHEREAL SULPHATES AND NEUTRAL SULPHUR PER KILOGRAM BODY WEIGHT WITH INCREASING PROTEIN INTAKE; FIGURES FOR TWENTY-FOUR-HOUR AMOUNTS

Protein per Kg. in Food, Gm.	Creatinin N per Kg., Mg.	Uric Acid N per Kg., Mg.	Ethereal Sulphates per Kg., Mg. SO ₃	Neutral Sulphur per Kg., Mg. SO ₃
2.3	5.3	7.4	6.5	11.8
4.4	4.4	2.4	3.3	16.3
4.8	4.6	3.8	2.7	10.8
5.9	4.2	...	3.0	12.5
7.1	4.5	...	3.6	13.4

first three periods was 0.47, 0.49, and 0.42. One of us, Gamble,¹⁶ found in an investigation carried on at the Boston Floating Hospital that when more than the usual amount of protein was given the A/NH₃ ratio fell, in other words, increasing the protein in the diet resulted in an increase of urinary ammonia out of proportion to its usual relation to the amount of titrable acid. We regret that the acid factors were not determined during the last two periods.

The ammonia coefficient, that is, ammonia nitrogen divided by the total nitrogen for the first three periods, were 20 per cent., 8 per cent., and 7 per cent. The coefficient of 20 per cent. for the first period is very high and might be taken to mean an excess of acid excretion. This, however, is not the case, as is shown by the absolute values for ammonia and titrable acidity, which are practically the same in all three periods. The seemingly high coefficient is due to a low total nitrogen in the urine, because of the low protein intake. Since a high ammonia coefficient is generally taken as evidence of acidosis, it is important to bear in mind that when the food contains only a small

16. Gamble: Not yet published.

amount of protein, a high ammonia coefficient will not necessarily mean acidosis. If, on the other hand, there is an average amount of protein in the diet, a high ammonia coefficient is of greater significance.

The urea nitrogen increased regularly with the amount of nitrogen in the food, as it does in adults, and indicates the extent of the exogenous protein metabolism.

The creatinin in the urine remained extremely constant in the total amount, and independent of the quantity of protein metabolized. It measures the endogenous metabolism of the individual. Previous investigators have found that the excretion of creatin in the urine of man is independent of the amount of protein in the food.

Our figures show that the amount of creatin in the urine of this infant depended on the amount of protein in the food. It increased

TABLE 6.—SUMMARY OF ENERGY—

Date	Body Weight and Surface	Height, Cm.	Age, Mo.	Carbon Dioxid per Hour, Gm.	Respiratory Quotient
5/21/14	4.74 Kg.	60	5½	6.48	....
	$10.3 \sqrt{w^2} = 0.291 \text{ Sq. M.}$			5.02	0.88
				6.04	....
5/23/14	4.75 Kg.	60	...	7.94	....
	$10.3 \sqrt{w^2} = 0.291 \text{ Sq. M.}$			4.72	0.84
				6.53	....
6/ 9/14	5.12 Kg.	62	6	7.6	....
	$10.3 \sqrt{w^2} = 0.306 \text{ Sq. M.}$			5.9	0.92

* Periods were of least activity according to the kymograph records.

with the protein as did the urea. It seems likely, therefore, that the creatin in the urine of this infant was a product of his exogenous metabolism.

The uric acid was highest with the lowest protein intake.

The ethereal sulphates, according to Folin, are almost entirely the product of endogenous metabolism. Table 3 shows that in our baby the ethereal sulphates were unaffected by the increase of protein in the food. The inorganic sulphates increased regularly with the increase of protein in the food and are, like urea, a product of exogenous metabolism. The neutral sulphur is, however, roughly constant.

Table 4 shows the amount of ammonia in the stools, which may be taken as an index of intestinal putrefaction. It increased with the increasing protein intake. This substantiates other findings of

Gamble,¹⁷ but does not show any relation between the ethereal sulphates of the urine, which remain absolutely constant, and the stool ammonia. The distinctly larger amount of ethereal sulphates, both total and per kilogram of body weight, in the period with the least ammonia in the stools seems to indicate that indol, phenol, and skatol in the intestinal canal do not contribute much to their formation.

The phosphates and chlorids in the urine increased with the increasing food protein in all five periods, while the undetermined nitrogen increased in like manner in the first three periods (the last two were not determined). It is possible that the undetermined nitrogen contains other products of the exogenous metabolism.

In Table 5 creatinin, uric acid, and the ethereal sulphates, products of the endogenous metabolism, are put on the per kilogram basis

—METABOLISM OF A BOY, F. W. L.

Heat Produced per 24 Hours, Calories		Rectal Temperature C. F.	Average Pulse Rate	Remarks
Per Kg.	Per Sq. Meter (Lissauer)			
..		36.8 (98.2)	127	Formula feeding (6 oz.) about ½ hour before the observa- tion was started
72	1,175*	.....	118	
87	1,412	36.8 (98.2)	127	
..		37.3 (99.2)	138	Formula feeding (5 oz.) about ½ hour before the observa- tion was started
70	1,144*	.....	117	
97	1,584	37.0 (98.6)	130	
..		36.9 (98.4)	142	Formula feeding (6 oz.) about 1 hour before the observa- tion was started
76	1,268*	37.1 (98.8)	137	

because it seems likely that the endogenous metabolism depends on the protoplasmic mass of the individual infant, just as does the total energy metabolism. The interesting point brought out in this table is that whereas the figures remain relatively constant during the last four periods, in the first period in which the protein approaches the minimum protein intake necessary for a nitrogenous equilibrium, there is a definite increase in the excretion of these three bodies, even though there was a small positive nitrogen balance in this period. Can it mean that the level of endogenous metabolism rises as the minimum protein intake necessary for a nitrogenous equilibrium is approached?

17. Gamble: Ammonia and Urea Content of Infants' Stools, *AM. JOUR. DIS. CHILD.*, 1915, ix, 519.

The basal energy metabolism¹⁸ was investigated between Periods 1 and 2, but no periods which could be considered quiet periods were obtained. Between Periods 2 and 3 two separate quiet periods were obtained, and between Periods 4 and 5 one quiet period was obtained. These periods are herewith recorded. Although the small number of periods does not justify any conclusions, it can be seen that the calories per square meter are distinctly higher with the higher protein intake than with the lower protein intake. These findings are, therefore, constant with those published from Lusk's laboratory.

SUMMARY

This work shows that the metabolism of F. W. L. was going on in a normal manner despite the increase of protein in the food. The baby gained weight very rapidly after he received sufficient calories to satisfy his appetite. Since he was considerably below the average weight for the age when the work commenced and gained so much weight during the investigations, the question may be brought up as to whether he falls into a similar class to that occupied by a patient convalescing from typhoid fever. It is impossible to answer this, but clinically he came into the class of babies "doing well."

The level of his metabolism varied because he needed more calories in the beginning, when he was underweight, than at the end, when he more nearly approached the normal weight for his age. During the last period he did not take all the food that was offered him, his natural instincts and appetite protecting him from a food that was ill balanced. This experience makes us speculate as to whether other investigators may not have had the same experience, and, for that reason, found no chemical evidence of a protein disturbance of metabolism. The endogenous metabolism of uric acid, creatinin and ethereal sulphates was maintained on a very constant level, while the exogenous metabolism, namely, urea, creatin, inorganic sulphates and the metabolism of phosphates, chlorids and undetermined nitrogen, increased with the protein in the food. The fat and carbohydrate absorption was within normal limits, although the fat utilization in Periods 1 and 5 was almost outside normal limits. The retention of nitrogen suddenly dropped in the last period, even though there was a greater intake and absorption of nitrogen. This loss was found in the stools, in which casein curds were found in large numbers. The ammonia in the stools increased with the increasing protein intake, and may be considered an index of intestinal putrefaction.

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18. The work was done with the apparatus of the nutrition laboratory of the Carnegie Institution of Washington.