

# A STUDY OF THE CALORIC NEEDS OF PREMATURE INFANTS

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The purpose of this paper is not to go into the details of the care and treatment of premature infants. It is rather to give such practical points and conclusions as have been arrived at after a study of the histories and development of the present series of seventeen cases, which have been selected, not because of their being ideal cases, but because they presented the different phases illustrated by proper under- and over-feeding as estimated by the caloric standard for nutritional needs as suggested by Budin, L. F. Meyer and others. The infants under discus-

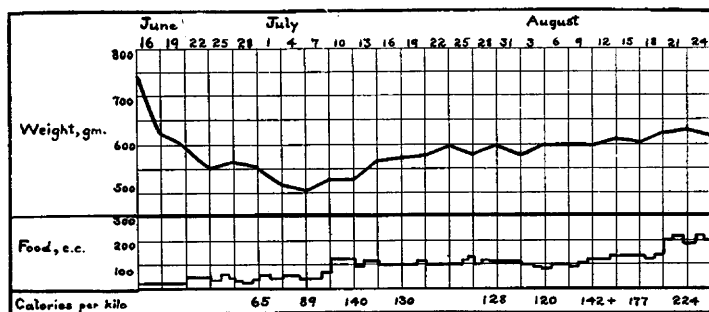


Chart 1.—Weight and food curves and calories per pound weight in Case 1. The patient entered June 16, 1916, aged 1 day; weight 740 gm.; condition bad; died Aug. 27, 1916; aged 75 days; weight 615 gm.

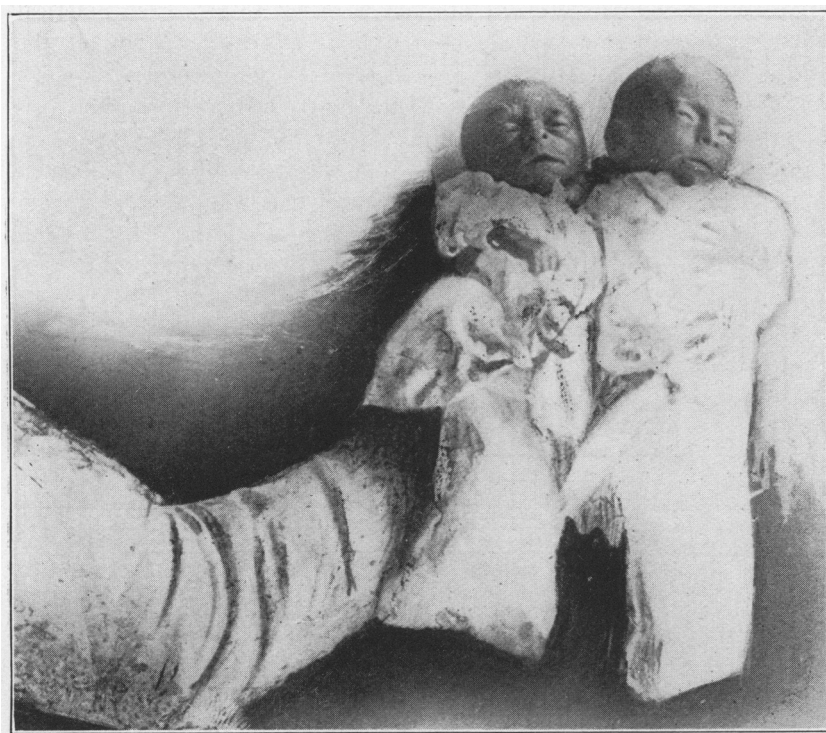
sion were fed rather according to the scale, with more especial attention to the temperature, stools, abdominal distention, cyanosis and general symptomatology, and only later their records were reviewed to ascertain the caloric intake. All except Infants 1 and 2 left the hospital in good health at the end of the period tabulated.

The infants have all been fed human milk exclusively while under my care. Those too weak to nurse have been catheter-fed or the Breech feeder has been used, while in those nursing, the milk taken has been estimated by weighing before and after feeding. The cases have been classified according to weight into those weighing under 1,000 gm., those between 1,000 and 1,500, and those over 1,500 gm.

CASES 1 AND 2.—Martha and Augusta were twins, born of a Greek family at 6½ months, and were delivered by a midwife. The mother visited the children at the hospital on the fourth day after their birth and on the following, the fifth

day, gave birth to a third, still-born fetus with a second placenta, and was again out on the ninth day. No less interesting were some of the deformities in the case of Baby Martha of this interesting group of triplets. She had but two fingers on one hand, and both knees and elbows were ankylosed in extension; in fact, there seemed to be an absence of the joint surfaces; while Baby Augusta had freedom of motion in all of her joints. Considering their prematurity,  $6\frac{1}{2}$  months, their weight at birth, 740 and 690 gm., respectively, together with the deformities in Baby Martha, it is surprising to find them surviving to 72 and 71 days, when both succumbed during attacks of cyanosis, due in all probability to over-feeding.

Because of Baby Augusta's better development, she was fed greater quantities from the start and although she did not have as great an initial fall in weight,



Photograph of twins, Cases 1 and 2.

both continued to lose until the twentieth day, Baby Augusta losing a total of 200 gm. and Baby Martha 230 gm. in this time. The records are rather incomplete as to the food given in Case 2 during this period. In Case 1, the estimates run from 65 to 89 calories per kilo. From the twentieth day on both infants showed almost stationary weight with food values below 120 and the greatest gain on an energy quotient<sup>1</sup> between 130 and 140; and death in both cases with an energy quotient of over 200.

CASE 3.—Baby Ethna, with a birth-weight of 1,360 gm., showed a steady increase after 137 was reached and continued to grow steadily until 220 was

1. Energy quotients were calculated by measuring the total quantity of human milk (in liters) fed in twenty-four hours and multiplying by 700 (caloric value of 1 liter of human milk) and dividing by the infant's weight (in kilograms).

passed, although the growth averaged only 12 gm. daily, being lower than several infants fed with a much lower energy quotient.

CASE 4.—Baby George, birth-weight 1,335 gm., had an average daily gain of 14 gm. with an average energy quotient between 95 and 161.

CASE 5.—Baby Hattie, birth-weight 1,435 gm., showed a daily gain of 17 gm. on an energy quotient of 116 to 148.

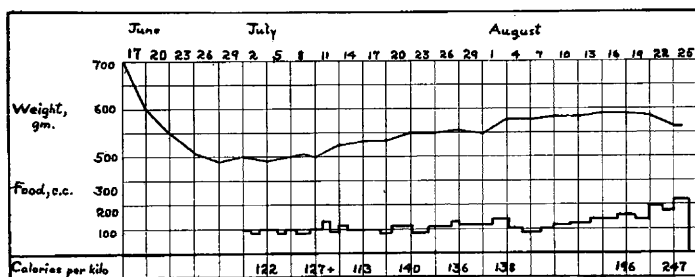


Chart 2.—Weight and food curves and calories per pound weight in Case 2. The patient entered June 17, 1910, aged 1 day; weight 690 gm.; condition bad; died Aug. 26, 1910; aged 74 days; weight 565 gm.

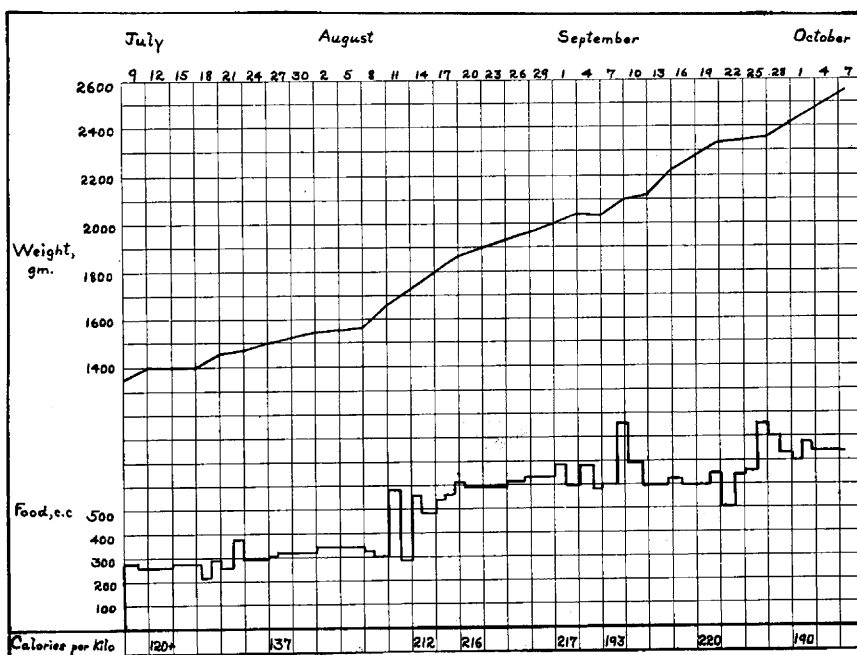


Chart 3.—Showing weight and food curves and calories per pound weight in Case 3. The patient entered the hospital, July 9, 1907, aged one day; weight 1,360 gm.; condition fair; discharged Oct. 5, 1907; aged 88 days; weight 2,512 gm.; condition good.

CASE 6.—Baby Nell-Helen, birth-weight 1,420 gm., showed an average daily gain of 27 gm. on an energy quotient of 115 to 144; the curve being more regular as the latter figure was approached.

CASE 7.—Baby Juanita, birth-weight 1,070 gm., has an ideal curve with an energy quotient ranging between 132 and 170, and an average daily gain of 14 gm. over a period of ninety days.

CASE 8.—Baby Grace, with a birth-weight of 1,440 gm., showed initial gain on 102 calories, followed by a loss when the same was reduced below 100; followed by a gain at 100, and a steady loss at 91; a moderate gain at 109; the loss was

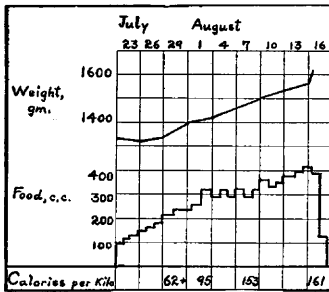


Chart 4

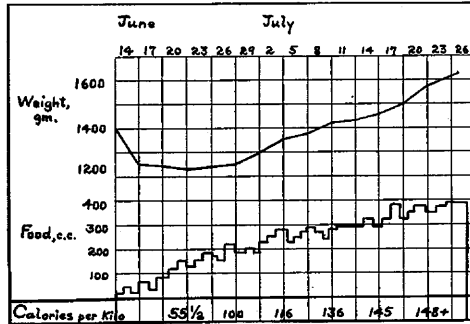


Chart 5

Chart 4.—Weight and food curves and calories per pound weight in Case 4. The patient entered July 23, 1910, aged one day; weight 1,335 gm.; condition fair; discharged Aug. 16, 1910; aged 24 days; weight 1,625 gm.; condition good.

Chart 5.—Weight and food curves and calories per pound weight in Case 5. The patient entered June 14, 1910, aged one day; weight 1,435 gm.; condition fair; discharged July 27, 1910; aged 43 days; weight 1,650 gm.; condition good.

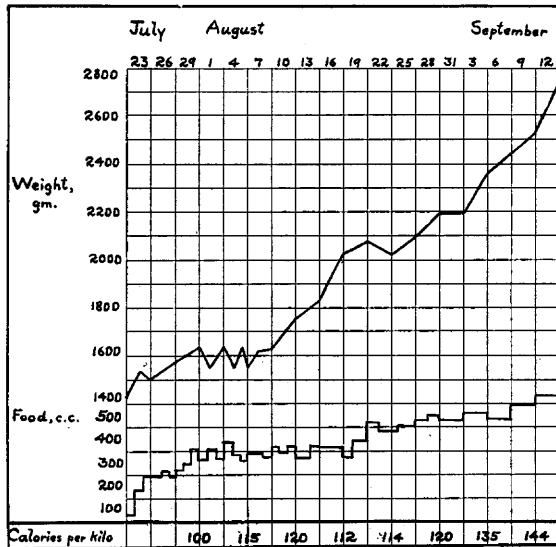


Chart 6.—Weight and food curves and calories per pound weight in Case 6. The patient entered July 23, 1907, aged one day; weight 1,420 gm.; condition fair; discharged Sept. 18, 1907; aged 57 days; weight 2,960 gm.; condition good.

again repeated at 90.5 and was followed by a rapid gain at 130 to 137, averaging daily 24.5 gm., and a less rapid growth, with greater fluctuations, at 115 to 109.5, averaging 10 gm. daily, and again rapidly rising with 124.

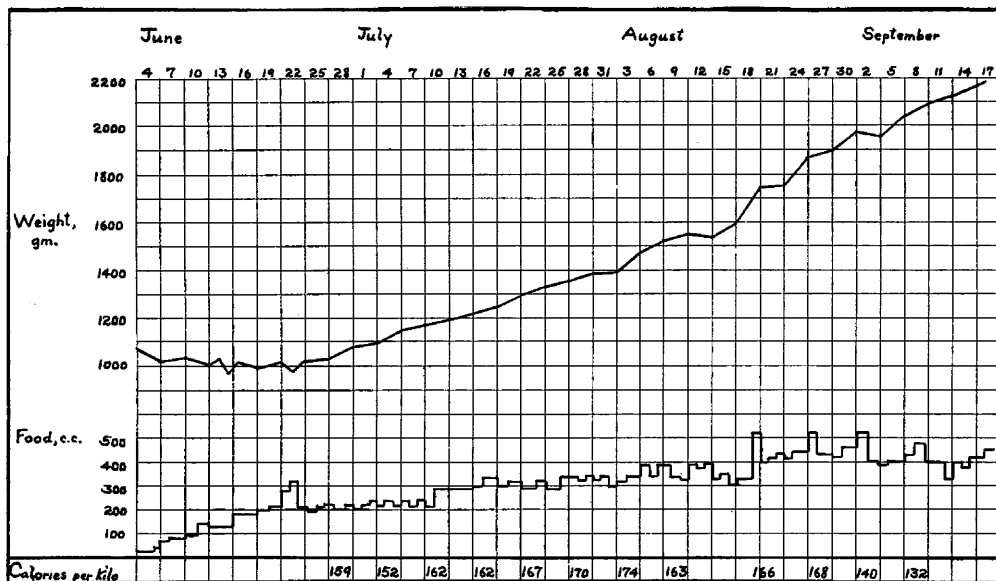


Chart 7.—Weight and food curves and calories per pound weight in Case 7. The patient entered June 4, 1910, aged one day; weight 1,070 gm.; condition fair; discharged Sept. 18, 1910; aged 105 days; weight 2,180 gm.; condition good.

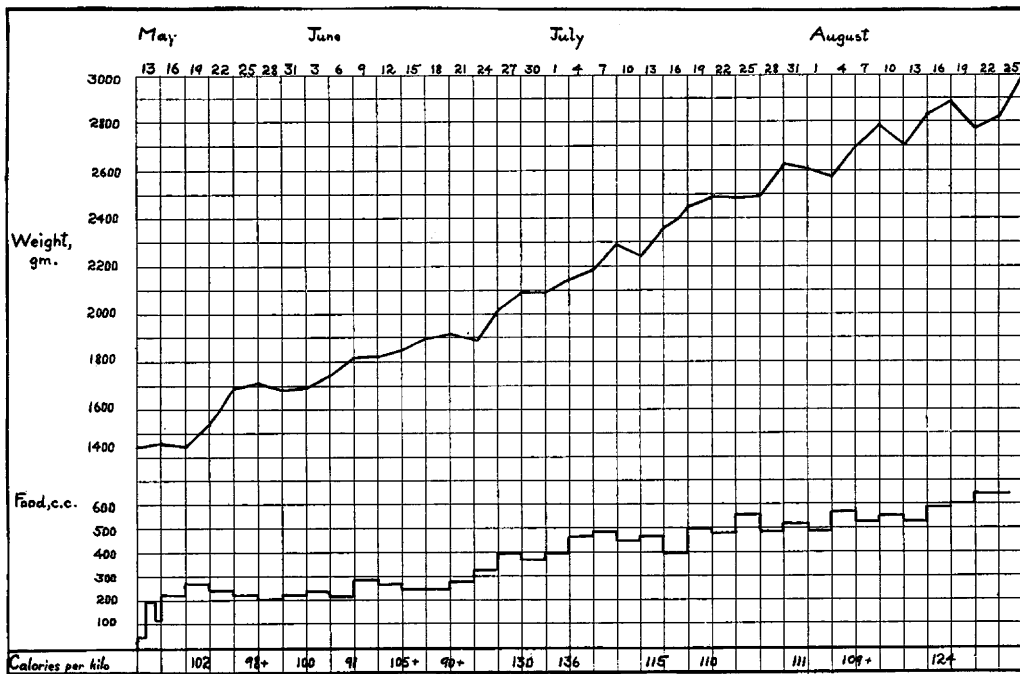


Chart 8.—Weight and food curves and calories per pound weight in Case 8. The patient entered May 13, 1907, aged 1 day; weight 1,440 gm.; condition fair; discharged Aug. 27, 1907; aged 106 days; weight 2,960 gm.; condition good.

In infants weighing between 1,500 and 2,000 gm. at birth, however, there is a more certain tendency to gain steadily at an energy quotient nearer 100. The ability of an infant to adapt itself to higher food values is beautifully illustrated in Case 9, Baby George, who gained steadily with only slight fluctuations on values gradually increased to 169.

CASE 10.—Baby Stella showed the most ideal curve with an average daily gain of 37 gm., gaining 1,130 gm. in one month on an energy quotient gradually increased from 105 to 131.

CASE 11.—Baby Marie first showed a gain at 104, continuing to gain on 102 and 119, but far less rapidly than Case 10, with its higher quotient, averaging only 21.5 gm. daily.

CASE 12.—Baby Martin Jo had a steady gain, averaging daily 18 on an energy quotient of 127 to 170, with an average daily gain of 9.5 on an energy quotient

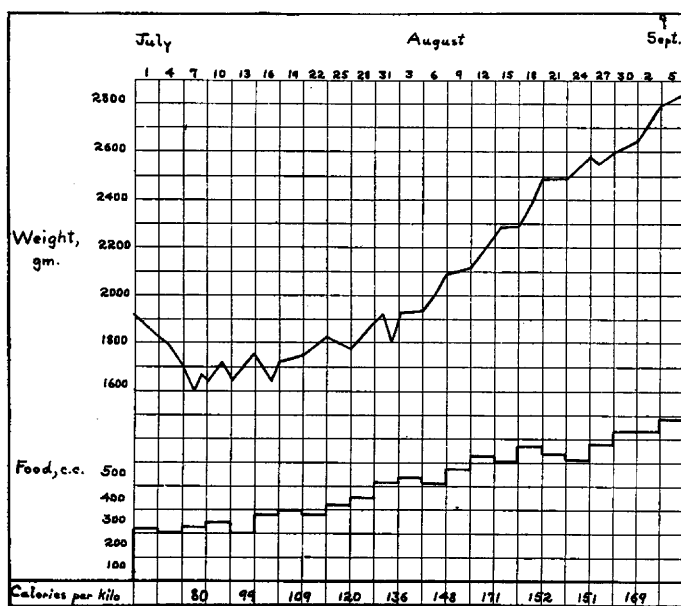


Chart 9.—Weight and food curves and calories per pound weight in Case 9. The patient entered July 1, 1907, aged 1 day; weight 1,935 gm.; condition fair; discharged Sept. 8, 1907; aged 69 days; weight 2,835 gm.; condition good.

between 170 and 206, associated with marked fluctuations and a tendency towards disturbed metabolic balance.

CASE 13.—Baby Jim shares with Case 10 the laurels of steady gain, and as in Case 10, the energy quotient is relatively low and the fluctuations small, averaging between 111 and 120, with an average daily gain of 40 gm.

CASE 14.—Baby Mike also presented a steady curve on an energy quotient ranging from 94.5 to 118.5. He was the largest child and, as is the rule, the larger the infant the smaller the energy quotient needed for increasing weight, the average being 43 gm. gained per day.

CASE 15.—Baby Marie, a smaller infant, showed her best gain at 125, with marked fluctuations in weight below 100.

CASE 16.—Baby Edythe showed another steady curve with regular gain with the energy quotient between 104.5 and 120, averaging 23 gm. daily increase.

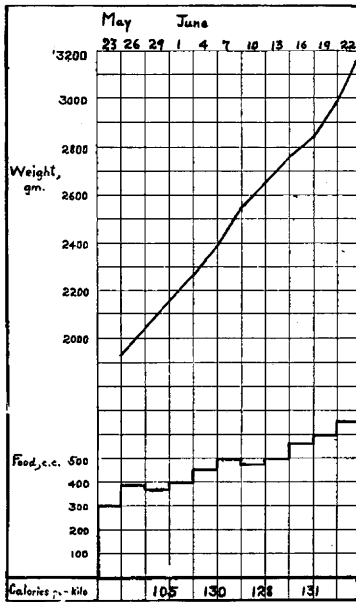


Chart 10

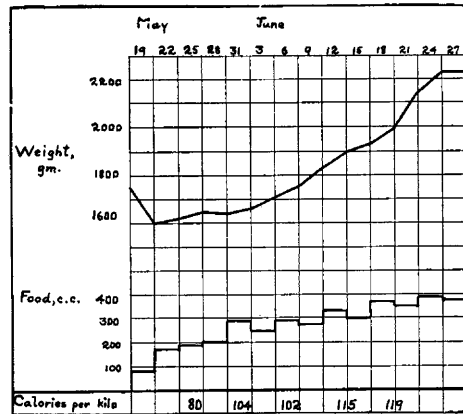


Chart 11

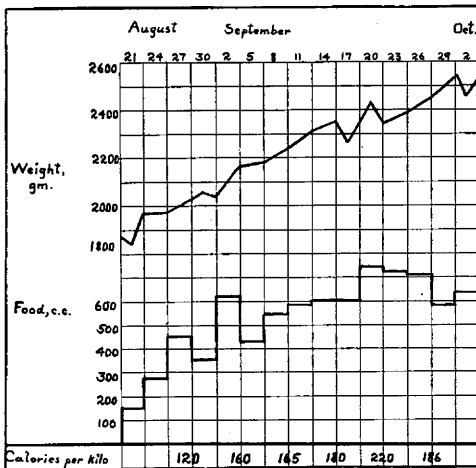


Chart 12

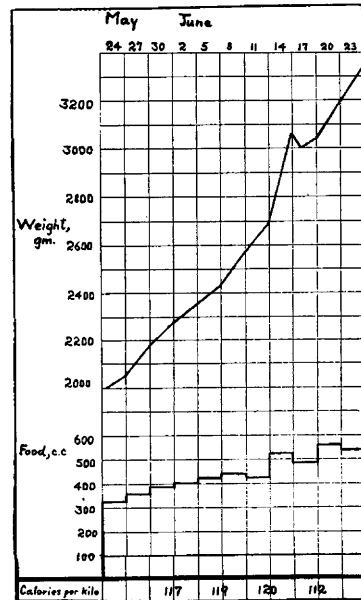


Chart 13

Chart 10.—Weight and food curves and calories per pound weight in Case 10. The patient entered May 23, 1909, aged 1 day; weight 1,930 gm.; condition fair; discharged June 22, 1909; aged 30 days; weight 3,160 gm.; condition good.

Chart 11.—Weight and food curves and calories per pound weight in Case 11. The patient entered May 19, 1910, aged 1 day; weight 1,750 gm.; condition fair; discharged June 28, 1910; aged 40 days; weight 2,225 gm.; condition good.

Chart 12.—Weight and food curves and calories per pound weight in Case 12. The patient entered Aug. 21, 1907, aged 1 day; weight 1,890 gm.; condition fair; discharged Oct. 5, 1907; aged 45 days; weight 2,515 gm.; condition good.

Chart 13.—Weight and food curves and calories per pound weight in Case 13. The patient entered May 24, 1909, aged 1 day; weight 1,950 gm.; condition fair; discharged June 26, 1909; aged 33 days; weight 3,315 gm.; condition good.

CASE 17.—Baby Josephine, although one of the largest in the series, weighing 1,960 gm. at birth, showed a loss of weight at 60.5, a minimum gain at 88.5 and a rapid gain between 105 and 132, averaging 25 gm. daily.

## DEDUCTIONS

1. The twins, weighing, respectively, 740 and 690 gm. at birth, showed regular gains in weight when the energy quotient averaged between 120 and 170; when 200 was passed death followed in both infants.

2. In a study of six infants with a birth-weight averaging between 1,000 and 1,500 gm., we find four infants with energy quotients fluctu-

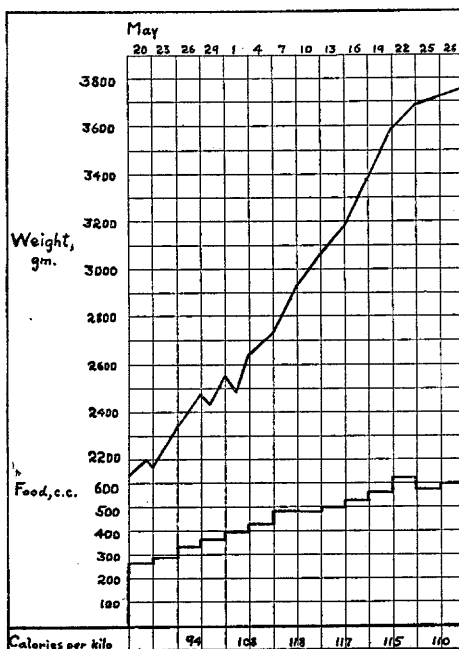


Chart 14.—Weight and food curves and calories per pound weight in Case 14. The patient entered May 20, 1909, aged 1 day; weight 2,010 gm.; condition good; discharged June 29, 1909; aged 40 days; weight 3,775 gm.; condition good.

ating between 115 and 170, averaging daily gains between 14 and 27 gm., while those with wider fluctuation, Cases 3 and 4, gained on an average 12 to 14 gm. daily.

3. Infants with birth-weights between 1,500 and 2,000 gm. showed the best results when being fed between 102 and 132. The largest infant with a birth-weight of 2,010 gm. gained on 94.5 to 118.5 apparently with equal rapidity, while Infant 12 showed marked fluctuations when an energy quotient was passed.



## CONCLUSIONS

In conclusion it is safe to state that the figures of Budin and others, of an energy quotient of 100 set for the full-term new-born infant, does not hold for the premature and under-weight infant, but I would say that the energy quotient needed, varies inversely with the age and birth-

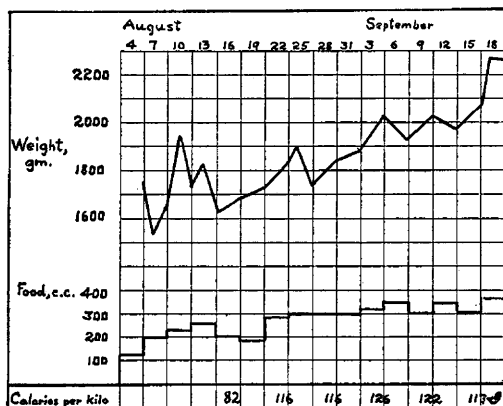


Chart 15.—Weight and food curves and calories per pound weight in Case 15. The patient entered Aug. 1, 1907, aged 1 day; weight 1,765 gm.; condition fair; discharged Sept. 18, 1907; aged 49 days; weight 2,120 gm.; condition good.

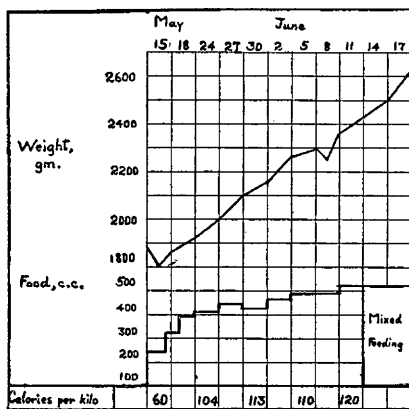


Chart 16

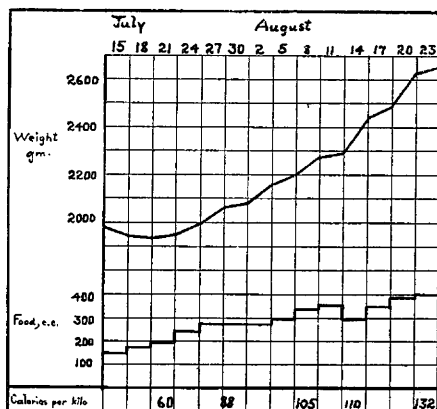


Chart 17

Chart 16.—Weight and food curves and calories per pound weight in Case 16. The patient entered May 15, 1910, aged 1 day; weight 1,875 gm.; condition fair; discharged June 16, 1910; aged 32 days; weight 2,615 gm.; condition good.

Chart 17.—Weight and food curves and calories per pound weight in Case 17. The patient entered July 15, 1907, aged 1 day; weight 1,960 gm.; condition fair; discharged Aug. 23, 1907; aged 39 days; weight 2,635 gm.; condition good.

weight, the energy quotient averaging between 115 and 170 in those below 1,500 gm. and 100 and 132 in those over 1,500 gm. These figures are not arbitrary, and, of all things, should not lead to an attempt to feed

these values in the first few days of life; otherwise a catastrophe will result. At first not only should the caloric value of the food be low, but the quantity of each feeding should also be small.

1. These infants, therefore, should be fed small quantities, frequently repeated, i.e., every one and one-half to two hours during the day and two to three hours during the night, according to the development of the individual, with special reference to the digestive organs, stools, urine and presence or absence of vomiting.

2. On the first day following the first bowel evacuation the human milk may be fed diluted with one or two parts of water or sugar, with a caloric value approximating 30.

3. From the second day on, in the absence of indigestion, the food may be increased by 10 calories daily. In the presence of digestive disorders greater care is necessary and it may be necessary for some days to hold the feeding in the neighborhood of 90, approximately the amount necessary to maintain the metabolic equilibrium.

4. After ten to fifteen days an attempt should be made to hold the figures, in the infant weighing less than 1,500 gm., to 120 to 140, and in those weighing over 1,500 gm. at between 110 and 130; but in all cases the infant itself should never be lost sight of, and more especially the stools and weight.

Budin's rule for the total twenty-four-hour quantity of milk to be given is very practical and is as follows: Feed one-fifth of the body-weight of the infant, or multiply the infant's weight by two and feed one-tenth of this amount. Budin used 650 calories to a liter of human milk as the basis for his estimation of the energy quotient, while in the figures I have given, I have figured the same as having a caloric value of 700, which would give an energy quotient of 10 higher with the latter; i. e., 130 with 650 as compared with 140 with 700 as a working basis.

5. Higher caloric needs of the premature are due to two factors — larger body surface proportionate to size and the consequent increased metabolic requirements. The early results quoted in my cases were obtained in infants raised in incubators, some of the later by the use of electric pads. It is quite necessary that all be provided with artificial heat whether from incubators, electric pads or hot water bottles, sufficient heating being used to cause the temperature to approach the normal. In incubators this ranges from 78 to 90 F. All of these methods are fraught with danger, and I have seen a temperature of 106 F. in an infant which was too close to the electric pad. The same dangers are attached to incubators.

One other important factor is a sufficient water-supply to counter-balance the rapid evaporation due to artificially heated and dried air and the excessive excreta of the first few days. As it has been my rule never

TABLE 1.—ENERGY QUOTIENT IN THE FIRST WEEKS OF AUTHOR'S CASES,\* AND IN FEER'S CASE

Case.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Birth-weight, gm..	3,615	690	1,360	1,335	1,435	1,420	1,070	1,440	1,935	1,930	1,750	1,890	1,950	2,010	1,765	1,875	1,960
Energy Quotient																	
by weeks—																	
First .....	89	...	120	...	14.7	100	...	102	80	105	80	127	117	94.5	100	104.5	60.5
Second .....	...	...	...	95	55.5	115	...	98.5	99	130	104	139	119	108	100	113.5	88
Third .....	...	122	137	163	100	120.5	159	100	109	128	102+	170	120	118.5	90	110	105
Fourth .....	...	140	127.5	161	116	112.5	152	91	120	131	115	170	112	117.5	125	120	132
Fifth .....	...	130	...	...	136	114	162	109	120	...	119	206	111	115	114	...	110
Sixth .....	...	112	128	...	...	145	120	162	...	136.5	...	...	...	110	...	...	...
Seventh .....	...	120	140	...	148	135	167	130	148	...	...	...	...	...	...	...	...
Eighth .....	...	120	136	...	...	144	170	136	171	...	...	...	...	...	...	...	...
Ninth .....	...	142.5	138	...	...	...	174	137	152	...	...	...	...	...	...	...	...
Tenth .....	...	97	177	...	...	...	163	115	151	...	...	...	...	...	...	...	...
Eleventh .....	...	224	247	...	...	...	...	...	...	...	...	...	...	...	...	...	...
(Died)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Eleventh .....	...	...	...	...	...	...	166	115	169	...	...	...	...	...	...	...	...
Twelfth .....	...	...	...	...	...	...	168	110	...	...	...	...	...	...	...	...	...
Thirteenth .....	...	...	...	...	...	...	140	111	...	...	...	...	...	...	...	...	...
Fourteenth .....	...	...	...	...	...	...	132	109.5	...	...	...	...	...	...	...	...	...
Fifteenth .....	...	...	...	...	...	...	...	124	...	...	...	...	...	...	...	...	...

\*All left the hospital in good health except Cases 1 and 2.

TABLE 2.—SHOWING RAPIDITY OF INCREASE IN WEIGHT IN AUTHOR'S CASES\*

Case .....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Birth-weight, gm.....	740	690	1,360	1,335	1,435	1,420	1,080	1,440	1,935	1,930	1,750	1,890	1,950	2,010	1,765	1,875	1,960
Gain by weeks, gm.—																	
First .....	165*	155*	40	15	185*	135	65*	200	300*	260	130*	130	175	240	50	85	25*
Second .....	...	35*	75	100	15	65	15*	...	50	250	45	175	235	150	120*	190	65
Third .....	...	...	5*	45	85	75	130	20	105	260	100	35	300	320	155	110	150
Fourth .....	...	25	35	45	90	65	290	80	105	50	265	175	35	390	210	190	90
Fifth .....	...	15	5	125	...	100	25	95	150	85	...	175	90	300	375	150	180
Sixth .....	...	5	5	175	...	135	225	95	125	275	125	...	...	360	190	...	...
Seventh .....	...	10	20	75	...	210	65	65	140	...	...	...	...	...	...	...	...
Eighth .....	...	15	10	75	...	300	100	240	100	...	...	...	...	...	...	...	...
Ninth .....	...	5	15	125	...	...	100	...	...	...	...	...	...	...	...	...	...
Tenth .....	...	20	10	50	...	...	75	140	140	...	...	...	...	...	...	...	...
Eleventh .....	...	...	...	125	...	...	75	112	...	...	...	...	...	...	...	...	...
Twelfth .....	...	...	...	...	...	...	175	50	...	...	...	...	...	...	...	...	...
Thirteenth .....	...	...	...	...	...	...	100	40	...	...	...	...	...	...	...	...	...
Fourteenth .....	...	...	...	...	...	...	115	30	...	...	...	...	...	...	...	...	...
Fifteenth .....	...	...	...	...	...	...	120	50	...	...	...	...	...	...	...	...	...

\*Loss in weight.

to start milk until after the first bowel movement, I have therefore found a frequent necessity for slight purgation with a minimum dose of castor-oil or milk of magnesia. I have endeavored to administer about one-sixth of the body-weight of water (inclusive of that contained in the milk) in twenty-four hours, and as in the smaller infants the first milk is given diluted one to four times during the first few days, it can be

TABLE 3.—SHOWING RANGE OF CALORIES AND DAILY GAIN

Cases	Range of Calories	Daily Gain gm.	Cases	Range of Calories	Daily Gain gm.
1. ....	.....	....	10. ....	105 -131	37.
2. ....	.....	....	11. ....	102 -119	21.5
3. ....	137 -220	12	12. ....	127 -170	18.
4. ....	95 -161	14		170 -206	9.5
5. ....	116 -148	17	13. ....	111 -120	40.
6. ....	115 -144	27	14. ....	94.5-118.5	43.*
7. ....	132 -170	24.	15. ....	114 -125	15.
8. ....	130 -137	24.	16. ....	104.5-120	23.
	109.5-115	10	17. ....	105 -132	25.
9. ....	90 -171	15.			

\*Largest baby.

administered partly with the food; otherwise between feedings or per rectum. Example: An infant weighing about 1,200 gm. should receive 200 c.c. of water; should this infant receive 50 c.c. of milk, this can be diluted with 50 c.c. or more of water or sugar solution and the remainder administered either per rectum or between feedings.

6. Disturbed metabolic balance with a standstill in the weight-curve and indigestion with bad bowel movements frequently resulted when 140 calories per kilo were exceeded.

TABLE 4.—ENERGY QUOTIENT STUDIES IN THE FIRST MONTH (FROM OPPENHEIMER)

Studied by	Feer (Normal Child)	Perutz	Hähner	Frick	L. F. Meyer
Birth-weight	3,615	2,470	1,620	1,800	750
Energy quotient by months—					
First	89	101	82	...	...
Second	112	127	119	122	...
Third	97	114	119	134	147
Fourth	92	107	111	121	155
Fifth	...	95	103	111	198

All intestinal disturbances in premature infants should be treated as if they were atrophic infants (decomposition — Finkelstein), as they do not stand starvation well. I have not attempted to speak of the artificial feeding of these infants as I believe it should be discouraged in all cases in which the infant is born at thirty-six weeks or under. Artificially fed, full-term infants also require a higher food-value than the same infants at the breast, the average added requirement being 10 to 20 calories per kilo, which would also hold true in premature infants, and this adds materially to the dangers of this method of feeding. The energy quotient

needed in my series of cases to maintain the metabolic equilibrium ranged quite close to 90, while in the full-term infant 70 is usually sufficient. The method of administration of food in each case varied with the vitality of the infant. In all cases of prematurity, syphilis should be thought of and in cases in which there is the slightest suspicion, the infant must not be placed directly on the breast.

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