HUNGER IN THE INFANT *

ROOD TAYLOR, M.D., Sc.D.

Mayo Clinic

ROCHESTER, MINN.

Cannon and Washburn,¹ and Carlson and his colaborers have given us a proved method for studying hunger objectively; its time of occurrence, its intensity, its effects, and the means by which it may be produced or inhibited. They have shown that contractions of the so-called empty stomach cause the hunger sensation. These contractions depend in part on vagus tonus. They can be increased by chemical changes in the blood, but are primarily due to a gastric mechanism as purely automatic as is that of the heart.

Impulses set up by these contractions and carried to the higher centers are, in the normal consciousness, recognized as hunger. These impulses produce secondary effects such as restlessness and irritability. They increase the reflex excitability of the central nervous system, the heart beats faster, and there are changes in the vasomotor mechanism. Well fed, sedentary adults seldom experience hunger. The prime factor in their desire for food depends not on the basis of distress due to the contractions of a hollow viscus, but on "the memory processes of past experience with palatable foods." This psychic factor is appetite, and its absolute distinction from the physical factor, hunger, must be kept in mind.

Working on dogs, Patterson, in 1914, showed the gastric hunger contractions to be much more frequent and vigorous in young than in older animals. In 1915, Carlson and Ginsburg described the great intensity of hunger contractions in the human new-born. Previous to that year no productive analytic studies of the hunger sense in the human infant had been made. Appetite and hunger were not distinguished, and the sucking mechanism alone had been analyzed.

In 1888, Auerbach distinguished the infantile type of sucking from the voluntary inspiratory type employed by the adult, and in 1894 Basch, disproving the older theory of Preyer that sucking is instinctive, showed it to be entirely reflex.

* Submitted for publication Aug. 18, 1917.

* From the Department of Pediatrics, University of Minnesota.

1. All references to the literature will be found at the end of the article.

Czerny, in 1893, observed that an infant awakened a short time after taking his fill from the maternal breast, would again suck vigorously if placed on it, and concluded that sucking per se could not be considered as a sign of hunger. A few years later (1900) Keller wrote that, since the normal infant sleeps three hours after nursing, although its stomach is empty in two hours, the emptying of the stomach cannot be considered a positive criterion of need for food. Pies, in 1910, considered the reddening and eczema of the lower lip which occurs in undernourished infants as a sign of hunger, and referred it directly to the infant's fruitless sucking. In 1913 Schlossmann concluded from extensive observations on semistarved infants that the sensation of hunger exists only in the imagination.

Meyer and Rosenstern studied the results of starvation in the different types of alimentary disorder, recording particularly the pulse, temperature, respiration and weight changes. Rosenstern later (1911-1912) wrote extensively on the general subjects of hunger and inanition in infancy. These studies are all defective in that they do not distinguish the various factors concerned. Neumann, Pfaundler, Cramer, Süsswein, Barth, and Kasahara have discussed the subject of disturbances in the food urge largely from the point of view of imperfections in the sucking mechanism.

The present studies are concerned particularly with the gastric factors in the urge for food. The major of these, the hunger contractions, was studied by means of apparatus similar to that used by Carlson. A rubber balloon of about 20 c.c. capacity attached to one end of a small soft rubber catheter is inserted into the stomach and inflated, the catheter is attached to a bromoform manometer with a cork float and a writing pennant which records the gastric movements on smoked paper.

The material investigated included 5 premature infants weighing from 1,200 to 2,500 gm., 40 full term new-borns under 3 weeks of age, and 11 older babies, 5 between 1 and 2 months, 2 between 3 and 4 months, 3 between 4 and 6 months, and 1 boy of 2 years with a surgically induced gastric fistula made necessary by the effects of corrosive in the esophagus. The gastric movements of some of the infants were recorded only once; on others as many as twenty observations were made.

Carlson and Ginsburg refer to the readiness with which most infants accept and retain the tube and balloon. It is naturally impossible to secure a graphic record of the stomach movements of a raging infant. Carlson and Ginsburg did their work on full term new-borns. These infants, as a rule, sleep quietly when not disturbed. The present work was carried on in a dimly lighted, quiet room. I had less difficulty when the infant was left undisturbed in his crib than when I

attempted innovations, such as threading a pacifier on the tube or having the infant held in the nurse's arms.

The older babies resent the presence of the tube, and with them it was often necessary to make repeated attempts to secure tracings. Some infants finally became accustomed to the presence of the tube and slept quietly, particularly if the experiments were conducted in the evening. Most of the tracings on the 2-year-old boy with the gastric fistula were made when he was awake. The greatest problem was to keep him sufficiently interested to prevent crying and restlessness and at the same time to prevent riotous hilarity. In his case the balloon was introduced directly through the fistula.

It is said that passage of the stomach tube in infants is apt to cause aspiration pneumonia. No ill results followed the procedure carried out in these studies.

Does the presence of the balloon in the stomach act mechanically to produce gastric contractions? Carlson states definitely that it does not, and gives the following reasons for his belief:

1. The presence of the distended balloon in the stomach between the contraction periods does not induce these contractions.
2. In Mr. V. [his gastric fistula case] the gastric contractions can be observed directly through the large fistula without any balloon in the stomach.
3. The contraction periods come on just as frequently without any balloon in the stomach and produce the same effect (hunger).
4. In pigeons the periodic strong contractions of the empty crop can be seen directly through the skin, and a balloon in the crop does not alter their frequency or intensity.

The results of this work fully confirm Carlson and Ginsburg's report that the stomach of the new-born infant exhibits greater hunger contraction than does that of the adult. The intervals between the contraction periods are often less than five minutes and usually not longer than from ten to twenty minutes. The first contraction period after a nursing is apt to consist of from five to twenty separate contractions and to last from two to eight minutes. The succeeding contraction periods frequently endure from thirty minutes to an hour or even longer. The duration of each contraction is about twenty seconds. In many of the infants the contraction time of the more powerful contractions, especially in those periods ending in partial tetanus, was about eighteen seconds. Except in the first contraction period after a nursing, endings in partial tetanus were frequently observed. Partial tetanus is sometimes present before the close of the period. With the apparatus used, the force of the single contractions usually sufficed to raise the column of bromoform 2 to 3 cm. During partial tetanus the bromoform may be raised 5 cm.

Patterson found practically continuous hunger contractions in premature pups. It is particularly easy to obtain graphic records of the

Fig. 1.—Hunger contractions in normal, new-born infant. Beginning of partial tetanus at extreme right in lower tracing.

Fig. 2.—Prematurely born infant. Typical activity of the premature baby's stomach. Boy F., aged 15 days; weight, 1,536 gm.; getting 45 c.c. breast milk six times a day. Previous feeding at 2:30 p. m.

hunger contractions of the somnolent, prematurely born infant. The stomach of such an infant is in a state of nearly continuous contraction. The individual contractions require about the same length of time for their completion and are as powerful as those of the full term infant. In a tracing begun forty minutes after a feeding of 15 gm. of breast milk to a premature baby (Baby 5) weighing 1,510 gm., the record appears very like that obtained by Rogers from the crop of a pigeon in the second day of starvation. The periods of contraction last two or three minutes, with intervening periods of quiescence of about the same length. The individual contractions last twelve to fifteen seconds and raise the bromoform column 3 to 4 cm. Partial tetanus is frequent. Nine days later, when the infant was receiving more food, in spite of the fact that he had not gained in weight and that the tracing was begun five hours after his last feeding, the record obtained was similar to those from other infants.

Are the hunger contractions more frequent or more powerful in cyanosed infants? May they furnish a stimulus for crying with consequent better aeration of the lungs? In two such cases no significant increase or decrease in the hunger contractions could be observed. No records were taken from any cyanosed premature infants, although such infants are frequently slightly blue for the first few days.

Carlson, working on the adult, was unable to produce hunger contractions by any sort of stimulus acting directly in the mouth or in the stomach, except that he occasionally could, by suddenly distending the stomach, produce a few transitory contractions. He found, uniformly, that the only effect of such local stimulation was inhibitory. In general, the taste of salt, sour, bitter, or sweet; or the chewing of agreeable, disagreeable, or indifferent substances, all produce temporary inhibition of the gastric contractions. Chewing palatable foods by the adult when hungry causes an inhibition, made more lasting by the flow of appetite juice in the stomach.

Carlson found that acid and alkaline solutions, food and liquids in the stomach, all inhibit the hunger contractions. Inhibition from the stomach is less transitory than that from the mouth. Boldyreff showed that the periodic contractions of the empty stomach were inhibited by the presence of acid in the intestine. Brunemeier and Carlson completed and enlarged this work. They demonstrated inhibition from the presence of gastric juice or acid chyme in the small intestine. This inhibition from the stomach and intestine is reflex, partly through Auerbach's plexus, but mainly through the long reflex arc with the efferent path to the stomach muscles through the splanchnics.

Inhibition from the mouth is not present in the frog (Patterson). Carlson, who suspects that such inhibition involves conscious cerebral processes, has suggested experiments in infants to settle the point.

Fig. 3.—Prematurely born infant; shows numerous short, forceful contraction periods. Boy Von, 4 days old; weight, 1,510 gm.; birth weight, 1,715 gm.; at 2:30 p. m. received 15 c.c. breast milk.

Fig. 4.—Baby Mi., 15 days old; tracing shows presence of hunger contractions in an infant who nursed poorly.

Repeated trials with breast milk, sugar water, common salt, quinin, and lemon juice in the mouths of premature and new-born infants in my study failed to produce inhibition of hunger contractions.

In general I obtained the same results in an infant of 8 weeks. A transitory inhibition occurred occasionally when sugar water was placed in his mouth. In none of the infants did chewing or sucking on the thumb or tube produce inhibition. Nor did such movements or the presence of sugar, breast milk or other substances in the mouth induce hunger contractions.

The boy of 2 years showed inhibition when sugar or protein milk (his diet at the time) was placed in his mouth. Quinin, dilute hydrochloric acid, small amounts of sugar water, table salt in crystals or solution, did not inhibit. Benzosulphinidum solution inhibited twice. It was not used subsequently. The sight of sugar did not inhibit. He began to cry when he saw his bottle if the latter were not given him immediately. Consequently the effect of his seeing the bottle on the hunger contractions could not be registered. During the periods of quiescence the sight of the nurse who fed him did not induce hunger contractions, although he began to whine and tease when she entered the room.

Apparently inhibition from the mouth was produced by those substances only which the child regarded as food. Quinin very evidently made a profound sensory impression, but did not inhibit the contractions. Dilute hydrochloric acid did not inhibit, while unsweetened protein milk (which is slightly sour) did.

Carlson's hypothesis as to the need of conscious cerebration for the production of inhibitory reflexes from the mouth would appear to offer the correct explanation. It seems to be agreed that the new-born infant leads a subcortical reflex existence (Soltmann-Cramer). Kussmaul and Thiemich note that the new-born infant accepts sugar and rejects salt, food that is sour and bitter — action which is almost certainly purely reflex on the part of the infant.

My work shows that when 20 c.c. of water or milk are introduced into the stomach during a contraction period inhibition follows invariably. This was found true in infants of all ages. With small amounts of water the inhibition often lasted only three or four minutes, when the contraction period would be resumed.

On the other hand, it was not unusual to recover from 15 to 40 cm. of clotted milk through the stomach tube even an hour after vigorous hunger contractions had begun. This is a considerable portion of the infant's meal, and in these cases would represent from one-sixth to one-fourth of his total intake at the previous feeding. Soltmann showed that the inhibiting nervous mechanism of the heart is much less effectual in the new-born infant than in later life. It seems possible

Fig. 5.—Baby Ri., 6 days old, with congenital myxedema; tracing shows presence of hunger contractions in a babe who nursed poorly.

Fig. 6.—Baby J., 4 months old. Tracing shows development of hunger contractions during the interval following a feeding.

that the nervous apparatus for the inhibition of the gastric hunger movements may likewise be immature. Or the tissue hunger may be so great as to overcome any but the strong inhibition of a heavily laden stomach and duodenum.

The vagi form the sensory pathway from the stomach to the brain. The first reflex centers are the sensory nuclei of the vagi in the medulla. A second center, possibly that for conscious hunger, is located in the optic thalami. Rogers has shown that the picking reflex in the pigeon (analogous to the sucking reflex in the babe) is abolished on removal of the thalami.

The reflex irritability (as indicated by the knee jerk) is increased synchronously with each hunger contraction (Carlson). No observations have been made on the infant's knee jerks during the hunger state; but Zybell has shown that the electrical irritability increases during the first eighteen hours of starvation.

Let us summarize the events from the close of one meal till the end of the next. The infant sleeps. The upper stomach musculature maintains a tonic grasp on the contained food. The pyloric antrum is traversed by peristaltic waves (Cannon). The stomach gradually empties. The point of origin of the peristaltic waves rises higher and higher. The tonus rhythm of the fundus begins. The stomach empties itself more completely, the tonus rhythm becomes more intense, and the first hunger contractions appear (Rogers and Hardt).

The first contraction period is apt to be short. After a wait of perhaps twenty minutes a longer and more intense hunger period arrives; then another and another. The infant's sleep becomes lighter. He is more easily awakened by external stimuli or by gastric discomfort. He is put to the breast, nurses vigorously, becomes fatigued (Schmidt, Cramer, Pfaundler), or experiences satiety from distention (Neisser and Bräuning) and again goes to sleep.

What constitutes the hunger state? Does it result from the summation of impulses with an increasing psychic and reflex irritability? The evidence is to the contrary. The increase in the reflex excitability is synchronous with the contraction phase of the stomach, and is absent in the intervals between the contractions. In the infant who has been some hours without food the hunger contractions are nearly continuous, and it would be expected that the reflex excitability would be nearly continuously high.

In the absence of hunger contractions the infant often sucks vigorously on the tube attached to the balloon. The receptive mechanism for the institution of the sucking reflex is so delicate that it is impossible to provide, artificially, a minimal stimulus. During the hunger state, when presumably a rapid succession of hunger contractions maintains a low reflex threshold, there may often be observed a succession of

Fig. 7.—Same as Figure 6.

automatic sucking movements involving the lips, tongue and lower jaw, each movement providing the necessary stimulus for its successor.

The lay mind is prone to think that the crying infant is hungry. Comby and Czerny and Keller believe that hunger is a minor cause of crying. Rosenstern notes that in hunger young babies are usually quiet, but that the older infants cry more. Schlossmann remarks that the normal infant endures hunger well.

Observations on this point extending over sixteen months of study of the hunger sensation lead me to believe that in normally thriving breast fed infants, except when more than three or four hours have elapsed since the last feeding, neither the hunger contractions themselves nor the increased irritability due to them are ordinarily immediate factors in the production of crying. Young infants sleep throughout strong contraction periods. Older infants often do the same, and are frequently quiet even from twelve to sixteen hours after a feeding. Mental factors produce crying at a very early age. And the fact that crying ceases when food or water is administered may only mean that the infant's attention is diverted to the performance of a pleasurable act.

It may be noted in this connection that the 2-year-old boy was happier when allowed to take food into his mouth, and that his outlook on life was much more cheerful on days when he could take nourishment by mouth than on other days when the esophageal constriction increased, and it became necessary to introduce the food through the gastric fistula. This feeding through the fistula was without pain, and the child submitted to it with some pleasure.

What is the time interval between feeding and the first appearance of gastric hunger contractions? Ginsburg, Tumpowsky and Carlson studied this point in thirty normal breast fed infants under 4 weeks of age. They gave no data as to gain in weight and did not determine the amount of food taken, but stated that the babes nursed till satisfied. They found the average time between nursing and the appearance of hunger contractions to be two hours and forty minutes, with a minimum of two hours and twenty minutes and a maximum of three hours and thirty minutes. My observations on twelve new-born infants under like conditions yielded these results; a minimum of one hour and thirty minutes, a maximum of three hours and thirty minutes, and an average of about two and one-half hours.

Many infants in the first two weeks do not receive a sufficient supply of breast milk. This is particularly apt to be true of the time the babe and the mother remain in the hospital. Consequently, observations made under the conditions so far outlined may be misleading. Table 1 (A, B and C) gives the results of all satisfactory tracings obtained from normally thriving babies on whom sufficient data as to food intake and weight gain were obtained.

TABLE 1.—INTERVAL FOR DEVELOPMENT OF HUNGER

A. PREMATURE INFANTS

Name	Age, Days	Food	Feeding Interval	Quantity at Feeding	Interval Before Tracing	Time for Development of First Hunger Period	Remarks
Sw.	7	Breast milk	4 hours	35 c.c.	None	40 min.	Premature Wt. 2,140 gm.
Sw.	11	Breast milk	5 times a day 4 hours	50 c.c.	20 min.	1 hr., 20 min.	Wt. 2,240 gm.
Sw.	20	Breast milk	5 times a day 4 hours	90 c.c.	52 min.	2 hours	Wt. 2,470 gm.
Sw.	25	Breast milk	5 times a day 4 hours	75 gm.	38 min.	1 hr., 50 min.	Wt. 2,565 gm.
St.	13	Breast milk	5 times a day 4 hours	30 c.c.	None	1 hour	Premature Wt. 2,270 gm.
St.	14	Breast milk	5 times a day 4 hours	50 c.c.	None	40 min.	Wt. 2,280 gm.
St.	25	Breast milk	5 times a day 4 hours	90 c.c.	1 hr., 13 min.	1 hr., 15 min.	Wt. 2,450 gm.
St.	28	Breast milk	5 times a day 4 hours	90 c.c.	38 min.	1 hour	Wt.
St.	36	Breast milk	5 times a day 4 hours	100 c.c.	32 min.	1 hr., 50 min.	Wt. 2,720 gm.
Fre.	9	Breast milk	5 times a day 4 hours	45 c.c.	1 hr., 38 min.	1 hr., 38 min.	Premature Wt. 1,380 gm.
Fre.	15	Breast milk	6 times a day 4 hours	45 c.c.	1 hr., 18 min.	1 hr., 18 min.	Wt. 1,530 gm.
Fre.	16	Breast milk	6 times a day 4 hours	45 c.c.	23 min.	1 hr., 15 min.	Wt. 1,535 gm.
Fre.	21	Breast milk	6 times a day 4 hours	65 c.c.	2 hours	2 hr., 20 min.	Wt. 1,710 gm.

B. FULL TERM NEW-BORN INFANTS

H.	8	Breast milk	4 hours	?	1 hr., 22 min.	3 hr., 50 min.	Wt. 3,590 gm.; gain in 4 days, 90 gm.
Dav.	8	Breast milk	5 times a day 3 hours 8 times a day	75 gm.	1 hr., 55 min.	2 hr., 25 min.	Wt. 4,160 gm.; gain in 5 days 260 gm.; 10 c.c. of milk clot removed from stomach 1 hr. after beginning of hunger contractions
Dav.	9	Breast milk	4 hours (for preceding 24 hours) 5 times a day	?	2 hr., 30 min.	2 hr., 30 min.	Wt. 4,200 gm.; gain in 6 days, 300 gm.; ½ c.c. thick mucus removed from stomach ½ hr. after beginning of hunger contractions
Wes.	8	Breast milk	4 hours	100 gm.	1 hr., 30 min.	3 hr., 10 min.	14 hours fast previous to last feeding
A.	9	Breast milk + cow's milk (aa 8% lactose)	5 times a day 3 hours 8 times a day	70 gm.	1 hr., 45 min.	2 hr., 10 min.	Wt. 3,610 gm.; gain in 6 days 230 gm.; 20 c.c. of thick soft milk clot removed from stomach 50 min. after beginning of hunger contractions
A.	10	Breast milk + cow's milk (aa 8% lactose)	.....	70 gm.	1 hr., 52 min.	2 hours	15 c.c. of fluid and curds removed from stomach 30 min. after beginning of hunger contractions
Wal.	10	Breast milk	4 hours	95 gm.	1 hr., 30 min.	4 hours	Wt. 3,240 gm.; gain in 6 days, 260 gm.
D.	12	Breast milk	5 times a day 4 hours 5 times a day	115 gm.	2 hr., 30 min.	2 hr., 30 min.	Wt. 3,720 gm.; gain in 7 days, 400 gm.

C. NORMAL INFANTS OVER TWO WEEKS OF AGE

Gor.	18	Breast milk	4 hours	85 gm.	2 hr., 23 min.	4 hours	Wt. 3,500 gm.; gain in 13 days, 70 gm.
Gor.	19	Breast milk	5 times a day 4 hours	110 gm.	1 hr., 58 min.	3 hr., 25 min.	
Way.	Mos. 3.5	Buttermilk + flour + saccharose	4 hours 5 times a day	150 c.c.	2 hr., 27 min.	3 hr., 12 min.	Wt. 4,960 gm.; gain in 7 days, 440 gm.
Way.	3.5	Buttermilk + flour + saccharose	4 hours 5 times a day	150 c.c.	57 min.	3 hr., 20 min.	40 c.c. of thick white material removed from stomach 20 min. after beginning of contraction period
Way.	3.5	Buttermilk + flour + saccharose	4 hours 5 times a day	150 c.c.	2 hr., 3 min.	4 hr., 35 min.	
Herm.	4	Breast milk	2 or 3 hours irregular	?	2 hr., 45 min.	3 hr., 30 min.	Well nourished; gaining in weight; normal baby; cared for at home; not in hospital
J.	4	Breast milk	5 times a day	?	2 hr., 15 min.	3 hr., 30 min.	Well nourished; gaining in weight; normal baby; cared for at home; not in hospital
Ad.	4	Malt soup	4 hours 5 times a day	125 c.c.	2 hr., 37 min.	3 hr., 30 min.	Wt. 3,500 gm.; gain in 2 weeks, 200 gm.; prematurely born; 1,600 gm. at birth

The time required for the development of hunger in the premature infant is noticeably short. In the case of the full term new-borns the figures obtained agree fairly well with those given by Ginsburg, Tumpowsky and Carlson, but are definitely greater than those obtained by me (mentioned in a preceding paragraph) from infants whose food intake was not accurately known.

The time required for the development of hunger in any one infant is fairly constant over a short period of time, provided the amount and kind of food is not changed. This conclusion rests not only on the results shown in Table 1, but on a dozen other observations on infants whose feeding conditions remained constant during the time in which studies were made.

With the older infants difficulty in maintaining quiet, after the insertion of tube and balloon, limits the number of observations which give positive evidence as to the first appearance of hunger contractions. Many less successful observations on healthy, normally developing infants yield this negative evidence that in such infants more than a month old I did not observe the development of hunger before the end of three hours.

It should be noted further that the contraction period, the first appearance of which is recorded in Table 1, is the first one to develop after feeding. This period is usually short and is not made up of forceful contractions. With Infants J. and A. more intense and more nearly continuous contractions did not begin for four and four and a half hours, respectively.

Habits as to feeding interval affect the time required for the development of hunger chiefly as they influence the emptying time of the stomach. It has been shown that the speed of gastric emptying is proportional to the length of time during which the individual has been without food (Tobler, Haudek and Stigler), and that large feedings are emptied with relatively greater rapidity than small ones (Tobler and Bogen). Habits undoubtedly exert a more powerful influence on the mental factors associated with appetite than on hunger itself.

Tables 2, 3 and 4 illustrate the shorter time required for the development of hunger in infants with chronic nourishment disturbance, and indicate that the presence of hunger contractions is not in itself evidence that the stomach is ready for food.

In the columns headed "Remarks" in Tables 1, 2, 3 and 4, there are notes as to material recovered with the stomach tube after the onset of gastric hunger contractions. In normal babies, however, there probably does exist a relation between the emptying time of the stomach and the interval for the development of hunger.

Observations on the emptying time in infants, so far reported, have been made either with the relatively stiff catheter, the stomach tube,

Fig. 8.—N. N., a 2-year-old boy with typhoid fever. Hunger contractions present when rectal temperature ranges between 104.4 and 105 F.

or the Roentgen ray. The flexible tube introduced by Reh fuss should replace the catheter for this purpose; it was used in my work. The literature contains no reports of the time required for gastric digestion in the premature infant. The emptying time in normal breast-fed infants under 1 week is usually less than one hour (Leo). The Roentgen-ray observations of Ladd and of Tobler and Bogen would indicate that in normal breast-fed infants the stomach is frequently not empty until after two to three hours. The figures obtained with the use of the stomach tube by Epstein, Czerny, Keller and Cassel indicate a delayed emptying time in gastro-intestinal disease.

TABLE 2.—HUNGER IN ATROPHY RESULTING FROM CONTINUED STARVATION

N. N., aged 2 years; gastric fistula; weight fluctuating between 6,800 gm. and 7,200 gm.; typhoid fever Dec. 1 until Dec. 14, 1916.

Date 1916	Food	Time of Last Feeding	Beginning of Tracing	
10/19	Diluted cow's milk + general diet	6 a. m.	10:15 a. m.	Practically continuous hunger periods until 10:50 a. m.
10/20	Diluted cow's milk + general diet	10 a. m.	2:12 p. m.	Practically continuous hunger periods until 3:15 p. m.
11/ 1	.....	10 a. m.	2:16 p. m.	One hunger period at 2:45 p. m. to 2:50 p. m. Hunger contractions practically continuous after 3 p. m. until 4:50 p. m.
11/10	160 c.c. cow's milk at preceding feeding	2 p. m.	2:45 p. m.	Observations continued until 5:10 p. m. No hunger periods, but child cried or was restless over half of the time
10/11	160 c.c. cow's milk at preceding feeding	2 p. m.	9:00 p. m.	Practically continuous contractions until 11 p. m.
11/11	200 c.c. protein milk + 7% dextrimaltose	5 p. m.	10:12 p. m.	Practically continuous contractions until 11 p. m.
11/12	200 c.c. protein milk + 7% dextrimaltose	5 p. m.	8:41 p. m.	First hunger period at 9:30; practically continuous from 9:45 on until 10:44 p. m.
11/29	200 c.c. protein milk + 7% dextrimaltose	1 p. m.	4:02 p. m.	First hunger period began at 4:35 p. m.; practically continuous from 5 p. m. on until 5:42 p. m.
12/27	200 c.c. protein milk + 7% dextrimaltose	9 a. m.	12:34 p. m.	Hunger periods practically continuous until 1:30 p. m.
12/28	200 c.c. protein milk + 7% dextrimaltose + cereals	9 a. m.	12:22 p. m.	Hunger periods began about 12:50; hunger periods became continuous after 1:20 p. m.
12/30	200 c.c. protein milk + 7% dextrimaltose + cereals	5 a. m.	10:13 a. m.	Practically continuous hunger periods until 11:20 a. m.

Major, using the Roentgen ray, finds the emptying time delayed in dyspepsia, but accelerated in decomposition. With the same method Pisek and LeWald found the emptying time to be shorter in infants with chronic disturbances of nutrition.

These last findings, taken in conjunction with the already quoted reports of Tobler, and of Haudek and Stigler, that the emptying time is shortened by hunger, are suggestive of the results here obtained experimentally; that is, the greater gastric hunger contraction in infants with chronic nourishment disturbance.

Not only is the interval for development of hunger shorter in such infants, but the contractions become much more intense. Nov. 10,

Fig. 9.—N. N., 2 years old. Tracing shows inhibition from sugar in the mouth; absence of inhibition from quinin in the mouth.

1916, the 2-year-old boy (Table 2), whose weight in spite of a calorically sufficient intake had remained stationary, and whose temperature had been irregular, developed fever and diarrhea. After eight hours of starvation, with temperature normal, the graphic record of his gastric activities resembled those of the starving pigeon and of the premature infant already mentioned. The contractions were continuous and required only twelve seconds for their completion. Next day the child was put on protein milk and thereafter improved.

It is generally agreed that mixtures with high fat content leave the stomach most slowly, while those with low fat and high carbohydrate

TABLE 3.—HUNGER IN EXUDATIVE DIATHESIS

Aus., 7 weeks old, Dec. 19, 1916. Feeding interval 4 hours, 5 times a day.

Date	Weight, Gm.	Food: Breast Milk + Butter-milk + Flour + Saccharose, C.c.	Time of Last Feeding	Beginning of Tracing	
12/19/16	4,450	100	1 p. m.	3:28 p. m.	Hunger contractions began at 3:30 p. m. Hunger contractions continuous from 3:55 to 4:37 p. m.
12/22/16	4,460	100	9 a. m.	11:49 a. m.	Hunger contractions present at 11:49 a. m. Hunger contractions continuous until 12:50 p. m.
12/22/16	4,460	150	1:15 p. m.	3:34 p. m.	Hunger contractions began at 5:45 p. m.
1/ 6/17	4,640	125	8 a. m.	10:55 a. m.	Hunger contractions began at 10:55 a. m. Hunger contractions continuous until 12:21 p. m.
1/ 8/17	4,640	125	8:40 a. m.	11:51 a. m.	Hunger contractions began at 12 m. Hunger contractions strong and continuous after 12:18. Babe was restless
1/11/17	4,650	125	8:45 a. m.	11:11 a. m.	Hunger contractions present by 11:45 a. m. Hunger contractions continuous until 1:35 p. m.
1/13/17	4,740	150	8:20 a. m.	11:03 a. m.	Hunger contractions began at 11:45 a. m. Hunger contractions continuous from 12 to 1 p. m.
1/15/17	4,770	150	8:45 a. m.	11:01 a. m.	Hunger contractions present at 11:20 a. m. Hunger contractions continuous from 11:30 a. m. until 12:50 p. m.
1/15/17	4,770	150	12:50 p. m.	3:21 p. m.	Babe cried a large part of time; no evidence of hunger periods until 5 p. m.

leave most rapidly. In Infants A. and W. the time interval for the development of hunger contractions was much longer when they received low fat and high carbohydrate, and shorter when they received high fat and low carbohydrate. This would be paradoxical if the gastric hunger contractions depended exclusively on the emptying time.

It is, then, only in normal babies, receiving well tolerated food in sufficient quantity, that the development of hunger waits on the emptying of the stomach.

The interval necessary for the development of hunger depends in part on the form of nourishment and is shortest with that food which least satisfies the infant's tissue need (Table 4). The question as to whether the rapid development of hunger in qualitatively poorly

Fig. 10.—Same child as in Figure 9. The tracing shows continuous short contractions in atrophy; after eight hours of starvation.

nourished infants depends on the administration of food deficient in carbohydrate in particular, or on the giving of food poorly tolerated in general, is not answered. Records of the gastric contractions in infants suffering from the chronic nourishment disturbance due to long continued carbohydrate overfeeding (the "Mehlnährschaden" of Czerny) would help to settle this point.

TABLE 4.—INTERVAL FOR DEVELOPMENT OF HUNGER IN INFANTS WITH CHRONIC DISTURBANCE OF NUTRITION AND SHOWING INFLUENCE OF CHANGE IN FORM OF NOURISHMENT

Name and Date	Age, Mo.	Diagnosis	Weight, Gm.	Food	Interval Before Tracing	Time for Development of First Hunger Period	Remarks
Til.	3	Atrophy.....	Stationary 4,080	120 gm. protein milk + 7% dextrimaltose 5 times a day	.....	.....	Hunger periods with partial tetanus less than 3 hours after feeding
Ad. 2/26/17	4	Chronic alimentary disorder due to overfeeding with milk	3,300	150 c.c. $\frac{1}{2}$ milk + 10% saccharose 5 times a day	.....	.....	Hunger contractions present in 2 hours and 20 minutes
Ad. 3/ 8/17	4	Chronic alimentary disorder due to overfeeding with milk	3,500	125 c.c. malt soup 5 times a day	.....	.....	Babe improved clinically; hunger contractions first appear in $3\frac{1}{2}$ hrs.
Way.	3	Chronic nourishment disturbance with eczema	.....	Mixture containing 8% fat. Feeding intervals short and irregular. After entrance to hospital fed 5 times a day	.....	.....	Entered hospital April 14, 1917
4/14/17	..	.....	4,200	150 c.c. $\frac{1}{2}$ cow's milk + 10% saccharose	2 hr., 7 min.	2 hr., 7 min.	Stomach emptied 3 hours after feeding; $\frac{1}{2}$ c.c. of mucus and thick curd obtained
4/23/17	..	.....	4,510	150 c.c. $\frac{1}{2}$ cow's milk + 10% saccharose	2 hr., 10 min.	2 hr., 10 min.	Eczema increased; 40 c.c. of clotted milk and clear thin fluid recovered from stomach 3 hours and 25 minutes after feeding
5/ 1/17	..	.....	4,960	150 c.c. buttermilk + flour + saccharose	2 hr., 3 min.	4 hr., 35 min.	Eczema has disappeared
5/ 2/17	..	.....	4,960	150 c.c. buttermilk + flour + saccharose	2 hr., 27 min.	3 hr., 12 min.	
5/ 3/17	..	.....	4,960	150 c.c. buttermilk + flour + saccharose	57 min.	3 hr., 20 min.	40 c.c. of thick white material removed from stomach 20 minutes after beginning of first contraction period

Attention has already been called to the heightened electrical reactions found by Zybelle in hungry infants. I also wish to mention the findings of Finklestein, Thiemich and Japha that the electrical irritability is frequently heightened in artificially fed infants, and of Czerny and Moser that there is an increase in the electrical irritability of infants suffering with "Mehlnährschaden." It is possible that the heightened electrical irritability in all depends on the increased hunger contractions due again in part to the constant chemical stimulation reaching the stomach from the semistarved tissues.

Most premature infants and many young infants nurse poorly. The consequent effect on lactation and on the babe's nourishment is serious. An extensive literature on this subject has been developed in German, but there is surprisingly little in French and in English.

In 1888 Auerbach described the infantile manner of sucking, which depends on the chewing muscles, and Escherich showed its teleologic importance. The reflex paths and center in the medulla were demonstrated in 1894 (Basch). Cramer, Suszwein, Finklestein, Rott, Rosentern, Barth and Kasahara have further studied the question and report results which in general support the theory that the inability to nurse well is to be attributed primarily to an imperfect nervous mechanism and not to muscular weakness.

For further elucidation of the question, tracings of the movements of the empty stomach were taken in two infants who were extreme examples.

The first baby (Baby M.), weighing 2,700 gm. at birth and presenting no anatomic peculiarities, took very little from the mother's breast during the first three weeks, although sufficient milk was expressed therefrom to feed the baby and to complement the feedings of other babies.

The second infant (Baby T.), aged 3 months, had weaned himself from the breast, had developed dyspepsia and atrophy on artificial feeding, and could be made to take his food from the bottle only with great difficulty. He seemed able to fix his attention on anything other than the act of feeding.

In these infants as well as in the five prematures, and in one typical case of congenital myxedema, hunger contractions of at least normal force and duration were present. At the time they were studied, none of the infants was able to nurse successfully. In all, the sucking reflex was qualitatively present.

This study does not solve the problem as to the causation of feeble nursing, but does limit the field of possibilities by excluding derangements of the primitive hunger apparatus.

Carlson reports Rupp's finding that hunger contractions persist during the fever excited by the administration of typhoid vaccine. The boy with the gastric fistula contracted typhoid fever from a carrier. Tracings taken while his rectal temperature ranged between 104.4 F. and 105 F., show the presence of hunger contractions.

Carlson and Ginsburg found hypertonicity and hypermotility in the stomachs of two infants with pylorospasm and stenosis. From a six weeks' old infant (Baby S.) with pyloric stenosis, I obtained records which agree with Carlson and Ginsburg's description of periods of tetanus lasting several minutes interspersed with vigorous contractions of normal duration.

Carlson suggests that pylorospasm and stenosis may be an expression of gastric hypermotility. His cases were seen late, as was the one here reported. In the absence of tracings taken at the beginning of the disease, it is likely that the hypermotility results from the inanition following the obstruction at the pylorus. And without definite knowledge that the stomach was washed empty, the long periods of tetanus observed may represent the so-called visible gastric peristalsis.

SUMMARY

The study of fifty-six infants from birth to 2 years of age gives the following results:

1. Confirmation of previous work, that hunger contractions are greater in the new-born infant, with description of these contractions.
2. Determination of the still greater hunger contraction in the stomachs of prematurely born infants, with description of these contractions.
3. There is no relation between cyanosis and hunger contractions.
4. Inhibition of the hunger contractions from the mouth does not occur in young infants.
5. Inhibition of the hunger contractions from the mouth in older infants is present only as the result of stimuli, which the babe has learned to recognize as food. It does not occur with substances producing equally strong sensory impressions, but which are not considered by the infant as food.
6. Inhibition from the mouth is psychic in character.
7. Reflex inhibition from the presence of food in the stomach is present in infants of all ages.
8. This reflex inhibition from the stomach may be only partially developed in young infants.
9. Successive automatic sucking movements—each sucking act serving as the stimulus for its successor—are present during the hunger state, when the reflex threshold is kept almost constantly low by a rapid succession of hunger contractions.
10. In normally developing breast fed babes, hunger is not ordinarily an immediate cause of crying.
11. The average time required for the development of hunger in healthy infants gaining in weight and receiving a known sufficient amount of food is, in prematures, under one month, one hour and forty minutes, with a maximum of two hours and twenty minutes and a minimum of forty minutes; in full term infants under two weeks, two hours and fifty minutes, with a maximum of four hours and a minimum of two hours; in infants from two weeks to four months,

three hours and forty minutes, with a maximum of four hours and thirty-five minutes and a minimum of three hours and twelve minutes (Table 1).

12. The time required for the development of hunger in any one infant is fairly constant over a short period of time provided the amount and kind of food is not changed (Tables 1, 2, 3 and 4).

13. The time required for the development of hunger in infants with chronic nourishment disturbance is shorter than in normal infants (Tables 2, 3 and 4).

14. The time required for the development of hunger is shorter when the infant receives food which is poorly tolerated (Table 4).

15. Hunger contractions occur in these infants long before the stomach has emptied. Consequently their presence is not in itself an indication that the stomach is ready for food.

16. The feeble nursing exhibited by most prematures and by many older infants is not due to derangement of the primitive hunger apparatus. Hunger contractions are present and of normal intensity in such infants.

17. Hunger contractions were present in one infant with congenital myxedema.

18. Hunger contractions were present in a 2-year-old boy with typhoid fever when the rectal temperature ranged between 104.4 F. and 105 F.

19. Confirmation of previous findings of increased hunger contractions in infants with pyloric stenosis.

I wish to express my sincere thanks to Dr. A. J. Carlson of the University of Chicago for suggestions which aided materially in carrying out these studies; to Dr. E. P. Lyon and Dr. A. D. Hirschfelder for the loan of apparatus from the departments of physiology and pharmacology; to Dr. F. H. Scott and Dr. F. B. Kingsbury for advice and assistance in the construction of apparatus; to Dr. F. W. Schultz for the use of material from the Infant Welfare Clinic; to Dr. N. O. Pearce, teaching fellow in pediatrics, and to head nurses Barber and Wenck, who cheerfully assisted in preparing the little patients for examination.

To my chief, Dr. J. P. Sedgwick, who first suggested this problem, and who allowed the free use of his material in the service at the university hospitals, I wish to express my grateful appreciation for constant stimulating interest and helpful suggestions.

REFERENCES

1. Auerbach, L.: Zur Mechanik des Saugens und der Inspiration. *Arch. f. Anat. u. Physiol.*, 1888, p. 59. Quoted by Uffenheimer: *Ergebn. d. inn. Med. u. Kinderh.*, **1**, 307-309.
2. Barth, H.: Untersuchungen zur Physiologie des Saugens beim normalen und pathologischen Brustkindern. *Ztschr. f. Kinderh.*, 1914, **10**, 129.
3. Basch, K.: Die Centrale Innervation der Saugbewegungen. *Jahrb. f. Kinderh.*, 1894, **38**, 68.
4. Boldireff, V. N.: Periodic Work of the Digestive Apparatus in an Empty Stomach, *Arch. Soc. de biol.*, 1905, **11**, 1. Quoted by Carlson, Footnote 9.

5. Brunemeier, E. H., and Carlson, A. J.: Contributions to the Physiology of the Stomach; XIX. Reflexes from the Intestinal Mucosa to the Stomach, *Am. Jour. Physiol.*, 1914-1915, **36**, 191.
6. Cannon, W. B.: A Consideration of the Nature of Hunger, Harvey Lecture, Phila., 1911-1912, **7**, 130.
7. Cannon, W. B., and Washburn, A. L.: An Explanation of Hunger, *Am. Jour. Physiol.*, 1911-1912, **29**, 441.
8. Cannon: The Mechanical Factors of Digestion, New York, Longmans, 1916.
9. Carlson, A. J.: Contributions to the Physiology of the Stomach; I. The Character of the Movements of the Empty Stomach in Man, *Am. Jour. Physiol.*, 1912-1913, **31**, 151.
10. Carlson, A. J.: Contributions to the Physiology of the Stomach; II. The Relation Between the Contractions of the Empty Stomach and the Sensation of Hunger, *Am. Jour. Physiol.*, 1912-1913, **31**, 175.
11. Carlson, A. J.: Contributions to the Physiology of the Stomach; III. The Contractions of the Empty Stomach Inhibited Reflexly from the Mouth, *Am. Jour. Physiol.*, 1912-1913, **31**, 212.
12. Carlson, A. J.: Contributions to the Physiology of the Stomach; IV. The Influence of the Contractions of the Empty Stomach in Man on the Vasomotor Center, on the Rate of the Heart Beat, and on the Reflex Excitability of the Spinal Cord, *Am. Jour. Physiol.*, 1912-1913, **31**, 318.
13. Carlson, A. J., Orr, J. S., and McGrath, L. W.: Contributions to the Physiology of the Stomach; IX. The Hunger Contractions of the Stomach Pouch Isolated According to the Method of Pawlow, *Am. Jour. Physiol.*, 1914, **33**, 119.
14. Carlson, A. J., and Ginsburg, H.: Contributions to the Physiology of the Stomach; XXIV. The Tonus and Hunger Contractions of the Stomach of the New-Born, *Am. Jour. Physiol.*, 1915, **38**, 29.
15. Carlson, A. J., and Ginsburg, H.: Contributions to the Physiology of the Stomach; XXX. The Tonus and Contractions of the Empty Stomach of Infants With Congenital Pyloric Stenosis, Pylorospasm and Chronic Vomiting (Merycism), *Am. Jour. Physiol.*, 1915, **39**, 310.
16. Carlson, A. J.: The Control of Hunger in Health and Disease, University of Chicago Press, 1916, p. 228.
17. Carlson, A. J.: The Control of Hunger in Health and Disease. See Footnote 16.
18. Cassel, J.: Zur Kenntnis der Magenverdauung bei Atrophia infantum, *Arch. f. Kinderh.*, 1891, **12**, 175.
19. Comby, J.: Traite des malades de l'enfance, Paris, Masson, 1902, p. 5.
20. Cramer, H.: Ueber die Nahrungsaufnahme der Neugeborenen. *Deutsch. med. Wchnschr.*, 1900, **26**, 32.
21. Cramer: Quoted by von Reuss, A.: Die Krankheiten des Neugeborenen, Berlin, 1914, *Enzyklop. d. klin. Med.*, p. 66.
22. Czerny, A.: Die Ernährung des Säuglings auf Grundlage der physiologischen Functionen seines Magens, *Prag. med. Wchnschr.*, 1893, **18**, 495, 510.
23. Czerny, A., and Moser, P.: Klinische Beobachtungen an magendarmkranken Kindern im Säuglingsalter, *Jahrb. f. Kinderh.*, 1894, **38**, 430.
24. Czerny and Keller: Des Kindes Ernährung, 1906, Part 1, p. 582.
25. Epstein, A.: Ueber Magenausspülungen bei Säuglingen, *Arch. f. Kinderh.*, 1883, **4**, 325.
26. Escherich: Ueber die Saugbewegung beim Neugeborenen, *Sitzungsb. d. Gesellsch. f. Morphol. u. Physiol. in München*, 1888, **4**, 72.
27. Finklestein, H.: Lehrbuch der Säuglingskrankheiten, Berlin, Kornfeld, 1905.
28. Ginsburg, H., Tumpowsky, I., and Carlson, A. J.: The Onset of Hunger in Infants After Feeding; A Contribution to the Physiology of the Stomach, *Jour. Am. Med. Assn.*, 1915, **64**, 1822.

29. Haudek, M., and Stigler, R.: Radiologische Untersuchungen über den Zusammenhang zwischen Austreibungszeit des normalen Magens und Hungergefühl, *Arch. f. d. ges. Physiol.*, 1910, **133**, 145.
30. Kasahara, M.: The Curved Lines of Suction, *AM. JOUR. DIS. CHILD.*, 1916, **12**, 73.
31. Keller, A.: Ueber Nahrungspausen bei der Säuglingsernährung, *Centralbl. f. Inn. Med.*, 1900, **21**, 393.
32. Kussmaul: Untersuchungen über die Seeleben des Neugeborenen, Quoted by von Reuss, 1859, p. 65. *Die Krankheiten des Neugeborenen*, Berlin, 1914.
33. Ladd, M.: Gastric Motility in Infants as Shown by the Roentgen Ray, *AM. JOUR. CHILD. DIS.*, 1913, **5**, 345. *Ibid.*, The Influence of Variations of Diet on Gastric Motility in Infants, *Arch. Pediat.*, 1913, **30**, 740.
34. Leo, H.: Ueber die Function des normalen und kranken Magens und die therapeutischen Erfolge der Magenausapülung im Säuglingsalter, Berlin. *klin. Wchnschr.*, 1888, **25**, 981.
35. Luckhardt, A. B., and Carlson, A. J.: Contributions to the Physiology of the Stomach; XVII. On the Chemical Control of the Gastric Hunger Mechanism, *Am. Jour. Physiol.*, 1914-1915, **36**, 37.
36. Major, R.: Roentgenologische Beobachtungen am Säuglingsmagen, *Ztschr. f. Kinderh.*, 1913, **8**, 340.
37. Meyer, L. F., and Rosenstern, J.: Die Wirkung des Hungers im den verschiedenen Stadien der Ernährungsstörung, *Jahr. f. Kinderh.*, 1909, **69**, 167.
38. Neisser, E., and Bräuning, H.: Ueber normale und über verzeitige Sättigung, *München. med. Wchnschr.*, 1911, **58**, 1955.
39. Neumann, H.: Ueber erschwerte Nahrungsaufnahme bei kleinen Kindern, *Therap. Monatsh.*, 1893, **7**, 220. *Abstr. in Arch. f. Kinderh.*, 1897, **22**, 152.
40. Patterson, T. L.: Contributions to the Physiology of the Stomach; XIII. The Variations in the Hunger Contractions of the Empty Stomach With Age, *Am. Jour. Physiol.*, **33**, 423.
41. Patterson, T. L.: Contributions to the Physiology of the Stomach; XXXVI. The Physiology of the Gastric Hunger Contractions in the Amphibia and the Reptilia, *Am. Jour. Physiol.*, 1917, **42**, 56.
42. Pfandler: Ueber Saugen und Verdauen, *Wien. klin. Wchnschr.*, 1899, **12**, 1012.
43. Pies: Zur Physiologie des Neugeborenen; Ueber die Dauer, die Grösse und den Verlauf der physiologischen Abnahme, *Monatschr. f. Kinderh.*, 1910, **9**, 514.
44. Pisek, G. R., and Le Wald, L. T.: The Further Study of the Anatomy and Physiology of the Infant Stomach Based on Serial Roentgenograms, *AM. JOUR. DIS. CHILD.*, 1913, **6**, 232.
45. Preyer: Die Seele des Kindes. Quoted by Baach, K.: *Jahrb. f. Kinderh.*, 1894, **38**, 68.
46. Quest, R.: Ueber den Einfluss der Ernährung auf die Erregbarkeit des Nervensystems im Säuglingsalter, *Wien. klin. Wchnschr.*, 1906, **19**, 830. Quotes: Finklestein: *Fortschr. d. med.*, 1902, **20**; Thiemich: *Revue d'hyg. et de méd. d. inf.*, 1903, **2**; Japha, A.: Ueber den Stimmritzkranke der Kinder. *Berl. klin. Wchnschr.*, 1903, **40**, 1126.
47. Rehfuss, M. E.: A New Method of Gastric Testing, With a Description of a Method for the Fractional Testing of the Gastric Juice, *Am. Jour. Med. Sc.*, 1914, **147**, 848.
48. Rehfuss, M. E., Bergheim, O., and Hawk, P. B.: Gastro-Intestinal Studies; The Question of the Residuum Found in the Empty Stomach, *Jour. Am. Med. Assn.*, 1914, **63**, 11.
49. Rogers, F. T., and Hardt, L. L. J.: The Relation Between the Digestion Contractions of the Filled, and the Hunger Contractions of the "Empty" Stomach, *Am. Jour. Physiol.*, 1915, **38**, 274.

50. Rogers: The Hunger Mechanism in Birds (Preliminary Report), Proc. Soc. Exper. Biol. and Med., 1916, **13**, 119.
51. Rosenstern, I.: Ueber Inanition im Säuglingsalter, *Ergebn. d. inn. Med. u. Kinderh.*, 1911, **7**, 332.
52. Rosenstern, I.: Hunger im Säuglingsalter und Ernährungstechnik, *Deutsch. med. Wchnschr.*, 1912, **38**, 1834.
53. Rott: Zur Ernährungstechnik frögeborener Säuglings, *Ztschr. f. Kinderh.*, 1912, **5**, 134.
54. Schlossmann: Ueber das Verhalten des Säuglings im Hunger. *Verhandl. d. Versamml. d. Gesellsch. f. Kinderh. . . . deutsch. Naturf. u. Aerzte*, 1913, Wiesb., 1914, **30**, 143.
55. Schmidt, A.: Brustsaugen und Flaschen saugen. München. med. Wchnschr., 1904, **51**, 2141.
56. Soltmann: Experimentelle Studien über die Funktionen des Grosshirns der Neugeborenen. *Jahrb. f. Kinderh.*, 1876, **9**, 106.
57. Soltmann: Ueber das Hemmungsnervensystem des Neugeborenen. *Jahrb. f. Kinderh.*, 1877, **11**, 101.
58. Süsswein, J.: Zur Physiologie des Trinkens beim Säugling. *Arch. f. Kinderh.*, 1904, **40**, 68.
59. Thiemich, M.: Ueber die Diagnose der Imbecillität im frühen Kindesalter. *Deutsch. med. Wchnschr.*, 1900, **26**, 34.
60. Tobler: Ueber die Verdauung der Milch im Magen. *Ergebn. d. inn. Med. u. Kinderh.*, 1908, **1**, 495.
61. Tobler and Bogen, H.: Ueber die Dauer der Magenverdauung der Milch und ihre Beeinflussung durch verschiedene Faktoren. *Monatschr. f. Kinderh.*, 1908-1909, **7**, 12.
62. Zybüll: Beiträge zur Behandlung der Spasmophilie. München. med. Wchnschr., 1911, **58**, 2357.