FAT METABOLISM IN INFANCY AND CHILDHOOD
WITH SPECIAL REFERENCE TO
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FAT METABOLISM IN INFANCY AND CHILDHOOD WITH SPECIAL REFERENCE TO INFANTILE ATROPHY, RICKETS, AND TETANY.

By

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The following paper is the outcome of an enquiry into the digestion and absorption of fats in infantile atrophy. The results obtained in this condition were sufficiently interesting to encourage me to conduct a similar enquiry into the fat absorption in rickets and tetany, conditions in which fat assimilation is considered to play a highly important part. I propose to deal with these diseases separately but as the conclusions arrived at apply in many respects to all three, they will be given at the end of the paper.

METHODS OF INVESTIGATION

The child under observation was placed on a metabolism bed for varying periods and the faeces passed per 24 hours were collected in waterproof sheeting, the urine being drained off into a bottle at the side of the bed by means of a piece of rubber tubing attached to the penis. The daily faeces output was transferred to a porcelain dish of known weight and the faeces were dried over a steam bath. The dried faeces, after being weighed, were ground up in a mortar into a fine powder and a sample of about 2 grams taken for analysis. The sample was placed in a silica basin and about 15 to 20 c.c. of ether were added. The dry faeces were then ground up in the ether which was then fil--tered through a fat-free filter paper into a fat extraction flask of known weight. The process was repeated several times till about 100 c.c. of filtrate were obtained after which the ether was distilled off and the residue dried and weighed. The residue contains neutral fats and free fatty acids. This was again dissolved in neutral alcohol and then titrated with N/10 NaOH. From this, the amount of free fatty acids was determined. The residue left from the original extraction was then treated with a few c.c. of 50% HCl and evaporated almost to dryness over a steam bath. By this means, the soaps were split up and free fatty acids liberated. These were then extracted with ether as before and weighed.

In a few cases, the soluble soaps, i.e. soaps of sodium and potassium, were determined by extracting a sample of faeces with hot water and filtering into a separation funnel. The soaps were then split with a little HCl and the free fatty acids xxtxx extracted with ether. The soluble soaps were small in amount and were practically always determined with the insoluble soaps, i.e. the soaps of calcium and magnesium.

1. INFANTILE ATROPHY.

Infantile atrophy, alimentary decomposition (Fink--elstein), or marasmus represents a symptom-complex in which wasting is the most prominent feature. Wasting may occur in many conditions but infantile atrophy is now generally regarded as including those cases only which correspond to Holt's defini--tion (1), viz. " the extreme form of malnutrition seen in infancy, occuring so far as is known without constitutional or local organic disease." This at once excludes diseases such as congenital syphilis, tuberculosis, pyelitis, chronic constipation, and others in which wasting is present. In all the cases examined by me, the above definition was adhered to. Infantile atrophy is to be looked upon as a definite clinical entity due to some error in the nutrition of the child.

It is doubtful whether infantile atrophy represents a single disease or not as the clinical picture given by various observers varies considerably. There are doubtless many stages of the condition but a well marked case presents the typical picture described in various textbooks. In my own experience of the condition the child, as a rule, takes his food well. Vomiting is not a prominent feature. It may be marked but in these cases where it does occasionally occur, a mouthful of milk only is brought up and not the whole contents of the stomach.

The condition of the bowels varies but my experience has been that, in the large majority of cases, the motions are loose but of good colour and well digested. These were observed in a considerable number of metabolism experiments where the urine was collected separately and the faeces passed into a waterproof sheet so that the water of the motions could not soak into the napkin and thus conceal the consistency of the motion as actually passed. They were found to be but little more bulky than in healthy infants, weighing on an average 11.9 grams (dried) as compared with 9.9 grams in health. In some cases the motions were greenish and undigested but this cannot be considered as typical of the condition since gastro-intestinal irritation is very liable to occur and it can be controlled by altering the diet.

Casein curds were sometimes present but, when these appeared, they tended to affect several children in the ward and did not confine themselves to the atrophics. Soft fat curds were not common. Soapy stools, as generally understood, were also pre--sent occasionally. It was found on examination that improvement in the condition was usually associated with more solid stools of a pale yellow or whitish colour, in which a high percentage of insoluble soaps was present.

The usual complications of the condition were frequently found, viz. suppurative conditions of the skin, attacks of gastro--enteritis, bronchitis, &c.

The pathology of this disease is very indefinite and post-mortem little abnormal can be found. Fatty infiltration of the liver is often present but this is not peculiar to infantile atrophy. There is shrinkage of the various organs but microscopical examination is negative. The fat content of the body is much diminished and in one estimation by Ohlmuller (2), the fat of an atrophic infant formed 3% of the body weight as compared with 21% in a healthy child. A somewhat similar result was obtained by Steinitz (3).

Regarding the aetiology of infantile atrophy, little is known. The primary cause is ascribed by Holt to a possible congenital weakness of constitution which may depend upon heredity but that in most cases it depends on food and surroundings. He believes that the condition of marasmus seems rather to be a failure of assimilation owing to imperfect digestion, improper food, unhygienic surroundings, or feeble constitution and states that the theory that atrophy of the intestinal tubules is the explanation of marasmus, finds little support from histological findings.

Still(4) gives a number of nutritional errors which may lead to atrophy but states that there is no satisfactory explanation for this. He is tempted to apply Sir William Gower's theory of "abiotrophy" and that it would appear as if certain infants have their function of assimilation endowed with so little staying power that it quickly falls into abeyance and marasmus results.

Czerny and Keller (5) ascribe infantile atrophy to certain dis--turbances of alimentation . These they call "milk injuries" and they further subdivide these into protein injuries, starch injuries, gluten injuries,and so on but this attempt to localise the causation of the condition to any one proximate principle is of doubtful practical value since their clinical manifesta--tion is seldom definite enough to be of value.

Pfaundler and Schlossman (6) state that the condition may be caused by exhaustion of the digestive function if the quantity of food is too great. These disturbances may be caused by an insufficient absorption resulting from anatomical injury to the absorption apparatus, diminishing of the oxidising power of the liver, intoxication from abnormal products of metabolism or to withdrawal of alkali and consequent encroachment upon certain neutralising bodies.

It seems to be widely held that in infantile atrophy there is a deficient absorption of fat. The results obtained, which will be considered later, vary considerably and this Talbot and Morse (7) explain by saying that in atrophy the metabolism of fat varies. This explanation, however, seems unsatisfactory. Clinically, one finds that feeding with a fat-weak milk mixture is followed fre--quently by improvement. In such cases, there must be a smaller absolute absorption of fat than in the case of a whole-milk diet. This would be evidence against defective absorption of fat being a cause and would point rather to some internal metabolic error. I propose therefore to consider the results of my enquiry into the digestion and absorption of fats in infantile atrophy and to see whether some reason cannot be found for the variable results already obtained.

Digestion of fat in Infantile Atrophy.

The amount of neutral fat present in the faeces is a measure of the fat splitting in the intestine and so is an indication of the activity of the pancreatic lipase. It has been stated by some authors (8) that there is a greater or less diminution or weakening of the digestive ferments in infantile atrophy and that this is especially true of the fat splitting ferment. Hecht believes that there is a connection between the severity of the disturbance and the diminution in the amount of lipase. In 22 examinations of healthy stools and 22 of atrophic examined by me, the extent of fat splitting, as measured by the neutral fat recovered in the faeces, is shown in the following table.

TABLE 1. Showing the percentage of fat split in the faeces fat.

	Maximum	Minimum	Average.
Healthy	100.0	87.9	95.2
Atrophic	100.0	71.4	91.9

There appears therefore to be no diminution or weakening of the pancreatic lipase and it must be concluded that in infantile

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atrophy, the digestion of fats is carried out as well as in normal infants. These figures correspond closely with the results of Keller and Hecht who found good fat splitting even in children ill for a long time. Keller, in six investigations, found 95% of the fat split. According to Freund, however, under certain pathological conditions (not stated), there is a lowering of fat splitting when fat absorption is interfered with and conversely, that low fat splitting leads to low absorption.

Absorption of fat in Infantile Atrophy.

The figures given by various observers for the percentage absorption of fat in atrophy show considerable variations. Freund (9) gives absorptions of 90% and 97% of fat in two cases of atrophy and in a third, 81.8%. The same author states (10) that even in chronic pathological conditions there is little loss of fat in the faeces and again (11) that the few estimations of fat absorption which have been made in sick infants allow us to conclude that at times a considerable portion of the fat escapes absorption, but metabolic investigations have not yet determined losses of fat of a sufficiently marked degree to jeopardise nutrition. He also states that the so-called soapy stools show no impairment of fat absorption and he gives tables showing a percentage absorption of over 90% in cases where the percentage of insoluble soaps in the faeces fat was high (10).

Bahrdt (12) gives results in cases passing soapy stools and here the percentage absorptions are given as 82.4, 33.2, 81.9, and 36.0 compared with 93% for a breast fed baby passing a normal stool. L.F.Meyer (13) examined an atrophic infant, receiving half milk, and found, during 5 periods, the percentage absorptions of fat to be 74.2, 24.9, 51.0, 68.3, and 78.6. Fife and Veeder (7) in two cases of atrophy found that the fat abs--orption was less than in healthy children.

Bosworth et alii (14) state that by decalcifying cow's milk, there is an increased absorption of fat. An analysis of their cases is given in Table 2. It will be seen that their results do not agree with those of Holt, Courtney, and Fales (15) who suggest that the bulk of the faeces in Bosworth's cases had something to do with the low absorptions. It will also be noted that my own results differ from both but an explanation of these differences will be given later.

TABLE 2. Analysis of percentage absorptions of fat.

% absorption of fat.	Percentage of cases in which different absorptions given.		
	Bosworth	Holt	Author
Over 95%	0.0	31.3	18.1
,, 90%	8.7	56.3	43.1
,, 84%	43.5	90.6	52.1
Under 80%	47.8	6.2	47.9

Talbot and Morse (7) remark that there is little doubt that increased peristalsis results in an increased loss of fat in the stools and that increased loss of fat may occur in any diarrhoea. Usuki (16) found that the addition of large amounts of malt extract to the food of the infant with alkaline stools caused the fat loss to increase from 10 to 15%. Talbot and Hill record similar results for lactose. They found that, with good digest--ion, the absorption of fat was 90% and that during a sugar ~~diar~~-

diarrhoea, it dropped to 75%. We have also the statement of Cammidge (17) that in artificially fed children, not only is the percentage higher but the absolute quantity of fat lost is incr-eased by more bulky motions being passed.

Finally we have the findings of various authors that the fat in-take has a considerable influence on fat loss. Freund (10) states that the percentage of loss is constant and Birk that the loss is proportionate to the intake. They both deduce from this that the food fat plays by far the most important role in faeces fat and that the fat derived from the intestinal secretions is negligible.

It will thus be seen that no definite conclusions with regard to fat absorption can be arrived at from the figures given above. The percentage absorptions given by various authors show great variations and it is probable that these are due to the operation of some common factor which has not been taken into account.

Results and Discussion.

In my examinations of the faeces, the sample taken was in each case approximately 2 grams and it was noted that the amount of fat extracted formed a fairly constant percentage of the dry faeces weight. It followed then that the total amount of fat lost in the 24 hours depended on the weight of dry faeces passed and that, with a large bulky motion, the amount of fat lost was considerable. I therefore agree with Cammidge's state-ment. It must be noted that, even with a loose motion, the amount of fat lost may not be great since, on evaporation of the water, the weight of the dry faeces might still be small. From

Charts 1 and 2, in which are plotted out the amount of diet fat, weight of dry faeces, and absolute amount of fat lost in the faeces, it will be seen that the fat lost varies in direct proportion with the weight of the dry faeces, and that, while the fat intake increases, the output remains more or less constant so that the proportion of fat lost diminishes as the intake increases. This is in agreement with v. Noorden's results which are as follows.

Fat intake Grams	Amount recovered in the faeces.
4.2	57.1%
42.2	10.9%
80.2%	6.3%

Table 3 shows the relationship between the weight of the dry faeces and the fat output. From this table, amongst healthy children, the average of the ratio, faeces weight to fat output, was 3.3 while amongst atrophics, it was 2.9. Taking both classes together, it was 3.1 so that it may be taken that the faeces fat forms approximately 1/3 of the dry faeces. This value agrees closely with that obtained for older children and adults (vide infra).

From Table 3, since the fat output forms such a constant of the dry faeces weight, it is clear that the percentage absorption obtained in any particular case will depend very closely on the faeces passed. In none of the papers of other observers is the weight of the faeces mentioned but the results just given would tend to bring into line the varying results obtained. Taking into consideration my absorption results as compared with those of Bosworth and Holt, (see Table 2), Table 4 will give the corresponding faeces weights.

TABLE 3. Showing the ratio between the weight of dry faeces and the weight of fat lost.

HEALTHY				ATROPHIC			
Fat intake in grams	Weight dried faeces in gms. a	Fat output in grams b	Ratio a/b	Fat intake in grams	Weight dried faeces in gms. a	Fat output in grams b	Ratio a/b
35.5	8.2	2.8	2.9	9.8	17.0	3.97	4.2
20.4	23.0	9.0	2.5	15.0	11.2	3.78	2.9
24.9	3.0	0.99	3.0	20.1	5.8	1.57	3.6
27.2	11.2	5.1	2.1	13.1	3.7	1.03	3.6
23.0	5.4	1.32	4.0	16.0	11.0	3.45	3.1
34.6	5.0	1.37	3.6	13.1	12.0	3.73	3.2
34.8	10.0	3.2	3.1	28.7	18.2	6.41	2.3
41.3	4.0	0.93	4.2	24.5	10.7	4.05	2.5
63.2	14.8	3.67	4.0	24.5	12.1	4.56	2.6
34.8	7.5	1.65	4.5	18.1	6.2	2.25	2.7
41.4	5.3	1.37	3.8	16.2	19.0	5.74	3.3
47.4	17.1	3.89	4.3	19.8	4.7	1.64	2.8
39.7	7.1	1.81	4.1	21.6	4.5	1.19	3.8
37.6	12.5	2.58	4.8	18.9	15.6	5.60	2.7
43.6	5.6	1.60	3.4	20.4	13.1	4.71	2.7
34.6	8.5	2.43	3.4	20.4	14.1	5.38	2.6
35.1	5.0	1.48	3.3	14.2	10.6	4.35	2.4
32.1	10.7	4.51	2.3	13.2	19.4	6.67	2.9
29.8	12.0	4.98	2.4	7.6	16.9	6.13	2.7
30.3	15.0	6.00	2.5	21.9	8.7	3.01	2.8
31.1	14.7	6.54	2.2	19.2	14.7	6.6	2.2
31.8	13.2	5.35	2.4	14.7	13.2	6.33	2.1
35.2	9.9	3.3	3.3	17.8	11.9	4.18	2.9

TABLE 4

Percentage absorption	Average weight of dry faeces in grams.	
	Healthy	Atrophic
Over 95%	5.3	-
,, 90%	7.9	4.7
,, 84%	8.1	5.6
Under 80%	18.8	14.5

This result is even more apparent in the following.

Percentage absorption	Average weight of dry faeces in grams.	
	Healthy	Atrophic
90 to 100	7.9	4-7
80 to 90	12.4	9.4
70 to 80	14.7	13.6
Under ~~80~~ 70	23.0	15.8

It is therefore very probable that the different results shown in

Table 2 are due to the different faeces weights obtained in the different cases examined.

It is obvious from what has been said that the bulk of faeces passed has a very important effect on the percentage absorption of fat. In any balance experiment the percentage absorption will depend on two factors; (1) the amount of fat ingested and (2) the amount excteted or the dry faeces weight since the fat excreted is about 1/3 of the faeces weight. The percentage absorption will vary with any disturbance of the relationship between these factors. The result can be expressed in the form of a general equation. If a represents the fat intake in grams and b the fat output, then the percentage absorption equals

$$\frac{100\ (a-b)}{a}$$

If the fat output, b, remains constant, then an increase in the intake, a, will raise the percentage absorption while if a remains constant, an increase in b will lower the percentage absorption and the limits will be reached when b equals 0 or b equals a. In the former, the percentage absorption will be 100 and in the latter, 0. It follows then that the percentage absorption varies directly with the fat intake and inversely with the fat output or the faeces weight so that, in order to judge whether a percentage absorption is normal or not, both these factors must in every case be taken into consideration.

In several cases examined, it was found that where the intake was approximately the same, the output varied considerably and consequently, the percentage absorption did also. What was the cause of this variation in fat output? Three reasons may be put forward,

1. Loss of fat through pancreatic insufficiency.
2. Increased loss of fat through excessively large motions being passed.
3. Increased loss of fat through some inability of the intestinal wall to absorb it. This is a true defective absorption.

The first point needs no discussion since it has already been shown that there is no defect in the fat splitting in infantile atrophy.

Regarding the loss of fat through excessively large motions being passed, very large motions indeed would be required if the fat lost is to be great enough to affect nutrition. The following will show in what a small degree this factor acts in infantile atrophy.

	Average weight of dry faeces per day in grams.	Average increased excretion of fat over healthy cases per day in grams.
Healthy	9.9	-
Infantile Atrophy.	11.9	0.83

That is, on an average, the atrophic loses only 0.83 grams of fat per day more than the healthy child.

In the third case, one is dealing with a true deficient absorption. Since the faeces fat forms about 1/3 of the dry faeces weight, any fat unabsorbed will go to increase the amount normally present so that the fraction 1/3 will be increased.

A reference to Charts 1 and 2 will bring out two important points. First, the fat intake has no influence on the faeces weight and secondly, with an increase in fat intake, the fat output remains more or less constant, any variations in the latter depending on, and varying directly with, the faeces weight. This is important because such variations in the fat output may affect the percentage absorption very considerably under certain circumstances. Table 5 will illustrate this.

TABLE 5. Showing the average percentages of fat absorption assuming that the total faeces fat forms 1/3 of the dry faeces weight.

Daily fat intake in grams.	Total fat in grams excreted = 1/3 dry faeces weight.						
	1	2	3	4	5	6	7
5	80.0	60.0	40.0	20.0	0.0	-	-
10	90.0	80.0	70.0	60.0	50.0	40.0	30.0
15	93.3	86.6	80.0	73.3	66.6	60.0	53.3
20	95.0	90.0	85.0	80.0	75.0	70.0	65.0
25	96.0	92.0	88.0	84.0	80.0	76.0	72.0
30	96.6	93.3	90.0	86.6	83.3	80.0	76.6
35	97.2	94.2	91.4	88.5	85.7	82.8	80.0
40	97.5	95.0	92.5	90.0	87.5	85.0	82.5
45	97.8	95.5	93.3	91.1	88.8	86.6	84.8
50	98.0	96.0	94.0	92.0	90.0	88.0	86.0
55	98.2	96.3	94.5	92.7	90.9	89.0	87.2
60	98.4	96.6	95.0	93.3	91.6	90.0	88.3

In Chart 6 are plotted out the graphs of the equation $\frac{100(a - b)}{a}$ for varying values of a and b, on the assumption that the fat output, b, is 1/3 of the dry faeces weight. From this it will be noticed that, when the fat intake is over about 20 grams, it begins to affect the percentage absorption much less than when the intake is below 20 grams. Thus, an intake of 20 grams with a faeces weight of 9 grams will give a percentage absorption of 85.0 while an intake of 35 grams will give an absorption of 91.4%.

a difference of 6.4%. A similar intake of 20 grams with a faeces weight of 9 grams will give a percentage absorption of 85.0 while with a faeces weight of 18 grams, the percentage absorp-tion will be 70%, a difference of 15%. When the intake of fat is low, the percentage absorption is influenced both by the intake and faeces weight but where the fat intake is high, the difference in intake may be neglected and the absorption will depend almost entirely on the faeces weight. Before one can say whether a percentage absorption is normal or not, it is absolutely necessary to consider the weight of faeces in each particular case and, to do this, it is necessary to see whether the result obtained approximates to the average absorption calculated for a certain fat intake and faeces weight. A reference to Table 6 will show how closely the observed and calculated results agree in healthy and atrophic children.

In two cases only could the absorption of fat be said to be def-icient to any marked extent, viz. an absorption of 19.5 instead of 26.1 and one of 56.9 instead of 70.0. It may therefore be concluded that, judging from this standard, there is no deficient absorption in atrophy. It will be noticed that the average per-centage absorption of fat in atrophy is 73.5 as compared with 89.3 in health and it might be thought from this that in the former, absorption was deficient but this difference is accounted for by the fact that, in the atrophic cases, the intake of fat was 17.8 grams on an average while in the latter it was 35.2 grams. It may therefore be concluded that there is no excessive loss of of fat from pancreatic insufficiency, excessively bulky motions, or from a true deficient absorption since the absorptions obtained approximate as closely to the calculated results as do those in healthy infants.

TABLE 6. Showing observed and calculated percentage fat absorptions in healthy and atrophic children.

HEALTHY CHILDREN		INFANTILE ATROPHY	
Percentage absorption observed.	Percentage absorption calculated.	Percentage absorption observed.	Percentage absorption calculated.
96.0	95.3	59.6	42.5
90.7	90.5	74.8	75.2
97.7	96.8	92.3	90.4
94.1	92.2	92.2	90.6
95.2	91.8	78.5	77.2
96.6	95.8	71.5	69.4
91.8	87.9	83.8	85.5
95.4	94.0	81.5	83.6
93.1	88.9	87.7	88.5
96.3	95.7	64.6	60.9
92.9	91.8	91.7	92.1
95.7	95.2	94.4	93.0
92.2	92.2	70.4	72.5
55.9	62.4	76.8	78.6
96.4	95.9	73.7	76.9
81.0	86.3	69.4	75.1
94.3	92.1	49.4	51.0
85.9	89.0	19.5	26.1
83.2	86.5	86.3	86.7
80.2	83.4	65.7	74.6
78.9	84.2	56.9	70.0
83.1	86.1	78.0	78.8
Av. 89.3	89.7	73.5	74.5

There is further evidence available to show that absorption of fat in infantile atrophy is not diminished. In Charts 1 and 2, in which the fat intake and output are shown, a steady increase in fat intake is accompanied by a practically constant output. The difference between the intake ordinate and the out--put ordinate represents the amount absorbed and it can be seen at a glance how this increases with increase in the intake. From the clinical side, there are certain facts against defic--ient absorption being a cause of atrophy. Improvement frequent-ly follows feeding on a fat-weak milk mixture prepared by diluting whole or pure milk with skim milk. This reduces the milk fat without affecting protein or carbohydrate. By mixing two parts of skim milk with one of whole milk, an approximate 1% fat milk is obtained and the calorific value of the diet is raised to meet requirements by adding sugar (vide weight charts attached). Such children, on this weak fat milk, absorb in abs-olute figures a much smaller quantity of fat than they do on a whole milk dietary so that evidently the condition is not due to a fat starvation.

2. RICKETS and TETANY.

The above enquiry into fat absorption was extended to rickets and tetany in order to determine whether, in the former, there was a diminished fat absorption corresponding to the defective calcium absorption present. The fat absorption in tetany was also examined in a few cases because of the close relationship of this complaint to rickets.

Digestion of fat.

As in infantile atrophy, there is no evidence of any defective digestion of fat in rickets and tetany. The following table shows the percentage of fat split in these diseases as compared with healthy children.

	Maximum	Minimum	Average.
Healthy	100.0	87.9	95.2
Rickets	100.0	81.6	96.3
Tetany	100.0	86.0	94.0

There is therefore no loss of fat in these conditions through pancreatic insufficiency.

Absorption of fat.

The same arguments given above can be applied also to rickets and tetany. In Table 7 are shown the observed and calculated percentage absorptions in these diseases and it will be seen that these agree fairly closely.

TABLE 7. Showing the observed and calculated percentage absorp--tions in rickets and tetany.

RICKETS		TETANY	
Percentage absorption observed	Percentage absorption calculated	Percentage absorption observed	Percentage absorption calculated
82.6	83.8	91.4	89.4
84.7	93.5	89.9	91.8
83.3	82.9	85.2	80.5
94.1	93.0	92.7	91.2
85.4	84.4	84.2	80.5
82.6	84.7	75.6	77.6
83.4	82.7	78.4	80.2
84.2	82.6	83.1	82.4
90.0	87.9		
90.9	94.9		
37.6	34.9		
78.7	69.1		
97.0	96.9		
56.1	64.5		
85.2	87.2		
81.1	88.0		
94.5	90.2		
89.0	88.7		
Av. 82.2	82.7	85.0	84.2

In a certain number of the cases of tetany, the fat intake was not determined and in these the percentage of fat in the ~~dryx~~ dry faeces was high. These results can be seen in the details of my metabolism experiments given at the end of the paper. There it will be noticed that the fat loss was high but, while this was due to very large motions being passed to a certain extent, the loss was about 11% higher than the average so that there is apparently some deficient absorption of fat in tetany.

Regarding the absolute quantity of fat lost in the faeces in rickets and tetany, in the former the average excretion was 3.96 grams and in the latter, 5.76 grams as compared with 3.3 grams in healthy children. The increased loss of fat in rickets per day over that in healthy children is only 0.66 grams and in tetany, 2.46 grams.

In Charts 3 and 4, the increase in fat intake is not accom--panied by an increase in output so that the more fat that is given to the patient, the more will be absorbed.

The loss of fat in rickets is thus practically the same as in health, and though in tetany there is a slight deficient absorption of fat, the excessive loss is in no way sufficient to jeopardise nutrition.

3. COMPOSITION OF THE FAECES FAT.

As mentioned above, there is a good digestion of fat in infantile atrophy and it is quite as efficient as in healthy infants. The average amount of fat unsplit inmthe faeces is about 6% of the total fat and this percentage does not vary much.

Soluble soaps also form a very small percentage of the faeces fat and here my results agree with those of Usuki in placing them at well below 10%.

The amount of fatty acids and soaps varies considerably but Chart 5 shows that they vary in inverse relationship with one another, thus confirming the results of Keller and Meyer. This also holds good for healthy children. It was thought from this that soap formation, i.e. insoluble soaps, occurred after absorption of the fatty acids was complete since other--wise one would expect the free fatty acids to be absorbed and so upset the inverse relationship. To settle this point, an ~~and~~ analysis of the faeces fat was made in a case of carcinoma with an intestinal fistula, said by the surgeon to be within two or three feet of the duodenum. The patient was receiving a dietary of strained soup, fish, eggs, milk, bread and butter and the following result was obtained,

	Percentage of dry faeces.	Percentage of total fat.
Neutral fat	0.45	2.43
Free fatty acids	5.65	30.58
Soluble soaps	5.80	31.40
Insoluble soaps	6.57	35.59

This shows that the insoluble soaps are just as abundant as in the faeces, but the striking thing is that complete fat splitting should occur so high up in the ~~duodenum~~ small intestine.

The iodine value of the fatty acids combined as insoluble soaps in the faeces is low and averaged 10. This shows how far the higher saturated fatty acids enter into soap formation. The iodine value of the total faeces fat was distinctly higher in healthy infants than in atrophics. This would indicate that atrophics absorb more of the unsaturated fatty acids than do healthy children. This is worthy of further investigation as this qualitative difference in absorption might offer some explanation of the increased metabolism in atrophy.

I do not propose to enter here into a discussion concerning the formation of soaps in the intestine. From the work of Freund (10), it seems that the main factor causing soap formation is the reaction of the intestine. Bosworth (14) claims that the degree of solubility of the food calcium is the factor which influences the formation of soaps and that a high calcium intake causes a serious loss of fat as soaps. This factor may also come into play by being the source of calcium, provided the reaction of the intestine is suitable.

However, what concerns us at present is whether a soapy stool is associated with a low absorption of fat. A soapy stool varies in colour from light yellow to gray. In some cases it is large and hard and in others, dry and crumbly. In my own cases, the stools were as a rule of putty like consistency but frequently, when a large motion was passed, they were semisolid. Naked eye appearances, however, are apt to be deceptive, and it would be better to limit the term " soapy stool" to one containing a high percentage of insoluble soaps irrespective of clinical appearances.

I have not been able to confirm Bosworth's statement. It is immaterial whether a large percentage of soap is present or not in the faeces because the soaps and free fatty acids vary in inverse proportion and, if the soaps are high, the free fatty acids will be correspondingly low and vice versa so that the total fat in either case forms approximately the same percentage of the dry faeces and the observed percentage absorption of fat is just as near the calculated result. This may be seen in Table 8. The absorption of fat, where a high percentage of soaps is present, follows the same rules as stated above and the percentage absorption will depend on the fat intake and faeces weight.

TABLE 8. Showing that the absorption of fat is not affected by the presence of a large amount of soaps in the faeces fat.

Percentage of soaps in total fat.	Percentage absorption observed	Percentage absorption calculated	Fat output per day in grams.
86.1	96.0	95.3	1.37
88.0	90.7	90.5	3.21
84.2	97.7	96.8	0.93
86.8	94.1	92.2	3.67
87.5	95.2	91.8	1.65
Av. 86.5	94.7	93.3	2.16
42.1	92.2	92.2	2.80
39.5	96.4	95.9	0.99
32.6	94.4	93.0	1.19
51.3	91.7	92.1	1.64
27.8	94.1	93.0	2.20
Av. 38.6	93.7	93.2	1.76

One is therefore forced to conclude that saponification of fats in the intestine in no way affects the absorption of fat. It has been my clinical experience to find soapy stools to be the rule when improvement sets in.

4. HAS FAECES FAT GOT A FUNCTION TO PERFORM ?

Is the faeces fat a pure excretion ? Does it represent merely the portion of fat unabsorbed by the intestine or is it left over in order to perform some function or other ?
It is certainly worthy of note that, not only in healthy infants and in infants and children suffering from infantile atrophy, rickets, and tetany, does the faeces fat form an approximate constant of the dry faeces weight but the same result is obtained in older children and in adults. In two children, aged about 3 years, convalescing from pneumonia, and on a milk diet, the

ratios of faeces weight to fat output were, during two periods, 3.6, 3.6, 2.9, and 3.5. In three adults, during one period, the fat of the diet was given as fat and, during a second period as fatty acid. In the first period, the ratios, faeces weight to fat output, were 3.1, 3.1, and 4.7 and in the second, 3.0, 3.9, and 3.2.

Observations were made on a dog on different diets with the following results.

Diet	Ratio: Faeces weight to fat output.
Milk and porridge	4.5
Half porridge, half meat	5.6
Whole meat	6.2
Half porridge, half meat.	5.9
Milk and porridge	5.2
Lemco, casein, rice (fat free)	7.1

These results may be compared with those of J.C.Drummond (18) in the case of rats. The animals were on a liberal diet for a period of 5 weeks. The following shows the ratio of faeces weight to fat output as calculated from his results.

Period	Ratio: Faeces weight to fat output.
First week	16.2
Second ,,	16.2
Third ,,	7.5
Fourth ,,	16.7
Fifth ,,	17.2

With the exception of the third week, it will be seen that the fat excreted in rats forms a very constant proportion of the dry faeces and it would seem as if a constancy in fat output similar to that in man exists for other animals as well though the values are different for each species.

It naturally occurs to one that the fat in the faeces acts as a lubricant to the bowel or that it prevents excessive absorption of water. In such a case, one would expect a diminution of the fat in constipation but this does not occur. Several of the motions examined were constipated but the percentage of fat was the same as in more normal ones. A paper by Holt, Courtney, and Fales (19) has just come to my notice and here it is stated that in constipated motions, there is a high percentage of soaps. It is therefore quite possible that not only is a certain proportion of fat in the faeces necessary but this fat must contain a cer--tain proportion of free fatty acids. If the soaps increase at the expense of the free fatty acids, constipation results while an increase in the proportion of free fatty acids results in loose motions.

A point which would appear to bear out this view is the occurrence of insoluble soaps so high up in the small intestine as shown by the examination of the contents of the bowel from anmintestinal fistula. One would have expected any free fatty acids to be absorb--ed but we find in the faeces that the soaps and free fatty acids bear an inverse relationship to one another so that apparently a certain quantity of fatty acids escape absorption. These either remain as fatty acids or are changed into soaps to a certain ex--tent, the degree of change depending on the reaction of the in--testine. It may be going too far to say that these fatty acids escape absorption, thus suggesting that they differ somewhat in composition from the fatty acids which are absorbed. It is quite possible that a process of absorption and re-secretion goes on. In one case, an adult, examinations of the faeces were made on a diet containing lemco, casein, and rice, i.e. a fat free diet, and here the percentage of fat in the faeces amounted to 23.2, a figure which approximates closely to the figures obtained for healthy subjects on diets containing fat. A somewhat similar result was obtained in the case of dogs (see above). This fat might be derived from fatty changes in the intestinal contents by bacterial action but more probably it comes from the intest-inal secretions.

The constancy of the fat output in relationship to the faeces weight and the occurrence of fat in the faeces after a fat free diet would suggest that the faeces fat has a function to perform and that it does not represent merely the unabsorbed portion of the diet fat. The fat may act as a lubricant to the bowel and though in constipation we do not find a reduction in the total faeces fat, there is, however, a qualitative change in that a high percentage of insoluble soaps are present. This high per-centage of soaps in a constipated motion and of free fatty acids in a loose one would also suggest that a certain balance between the soaps and free fatty acids was necessary. A possible explanation of constipation in the presence of a high percentage of soaps may be obtained from the recent work of Fischer and Hooker (20) on the physico-chemical properties of emulsions. These workers show that the breaking of an emulsion is easily accomplished by the addition of those substances which destroy or dehydrate the hydrophilic colloids that give an emulsion its original stability. The soaps of potassium, sodium, and calcium possess hydrophilic properties in very unequal degrees. The soaps of potassium and sodium can retain water to a considerable degree while those of calcium and magnesium have very little power of retention. A high percentage of such insoluble soaps in the intestinal contents would therefore tend to a larger absorption of water by the intestine and hence to constipation. On this ground, the faeces fat would not only act as a lubricant but, from the regulation of water absorption by the composition of the fat, it would also act by preventing excessive absorption of water and thus maintain motions of normal consistency.

5. THE ALKALINE RESERVE OF THE BLOOD IN INFANTILE ATROPHY.

As pointed out by Van Slyke and Cullen (21), the plasma bicarbonate represents the alkaline reserve of the body. This bicarbonate concentration of the blood is normally maintained at a definite level, and the entrance of free acids into the blood reduces this concentration to an extent proportional to the amount of the invading acid. Acidosis may therefore be defined as a condition in which the concentration of bicarbonate in the blood is reduced below a normal level.

In infantile atrophy, there is apparently no defect in the absorption of fat. Clinically, an atrophic child will frequently do better on a 1% fat milk mixture than on whole milk though in the latter case, the child will absorb in absolute figures a greater quantity of fat. It is therefore a question whether the non-improvement on whole milk may be the result of an inability of the child to metabolise completely the whole of the fat absorbed or, in other words, whether with whole milk there is, or is not, a diminished alkaline reserve of the blood owing to the system being flooded with the intermediate products of fat metabolism. To clear up this point, estimations of the plasma carbon dioxide bound as bicarbonate were made with the Van Slyke micro-apparatus.

In all the cases examined, the blood was drawn from a head vein directly into a centrifuge tube containing a small amount of potassium oxalate. It was at once centrifuged and the plasma was transferred to a small separation funnel and saturated with alveolar air. The estimation of the carbon dioxide was carried out within an hour or two.

In normal adults, plasma contains at 37 deg. Centigrade and normal carbon dioxide tension from 50 to 65% of its volume of carbon dioxide gas bound as bicarbonate. The figures in children are lower thanmin adults (Van Slyke). Schloss and Stetson (22) give the alkaline reserve or carbon dioxide combining power of blood plasma, values ranging from 46.2 to 76.1 (average 54.7) and again, Schloss and Harrington (23) give values from 49 to 72 volumes per cent in normal infants.

A few estimations of the alkaline reserve were made by me in infants under one year in order to determine whether they agreed with those of Schloss. The blood in these cases was taken about three hours after food as the children were healthy children about to be circumcised. They were practically all breast fed. In all cases, the nutritional state and nutritional trend were taken into account. The nutritional state represents the actual weight of the child shown as a percentage of the average weight of a healthy child of the same age. By nutritional trend is understood the trend of the child's weight at the time of examination, i.e. whether rising (R), stationary (S), or falling (F). In all the healthy children, the weight was equal to, or above, the average weight and, in all cases, the children were thriving and gaining in weight. The following table shows the results obtained.

Number	Age	Diet	Vols. carbon dioxide %
1	3 weeks	Nestle's milk	48.4
2	3 ..	Breast, Allenbury.	52.1
3	4 ..	Breast	51.6
4	4 ..	Breast	52.7
5	5 ..	Glaxo	48.1
6	5 ..	Breast	56.4
7	5 ..	Breast	47.9
8	6 ..	Breast	49.8
9	8 ..	Breast	48.9
10	10 ..	Breast	46.0
11	3 months	Breast	52.6
12	3 ..	Breast	55.5
13	3 ..	Breast, Nestle's	61.4
14	4 ..	Breast	44.8
15	4 ..	Breast	55.5
16	4 ..	Breast, S/Laura.	49.8
17	5 ..	Breast	51.6
18	6 ..	Allenbury II	45.3
19	7 ..	Glaxo	58.4

In this series of cases, the alkaline reserve of the blood is represented by values ranging from 44.8 to 61.4 with an average of 51.4 so that the results differ but little from those of Schloss

A similar series of observations were made in cases of infantile atrophy. These are shown in the table on the following ~~cases~~ page. The values obtained ranged from 29.0 to 58.7 with an average of 43.8. The low value in Case No. 2 was due to the fact that the patient was sinking rapidly. In all cases, with the ex--ception of No. 8, the motions were good and there was no vomiting. The results do not show that the alkaline reserve is any higher on a 1% fat milk diet than on whole milk, and though on the whole lower than in healthy children, there is evidently no acidosis of any consequence present or if there is, it is well compensated. That some compensation may be present is shown by the clinical

No	Age	Diet	Nutri--tional state	Nutri--tional trend	Volumes Carbon dioxide
1	9 mos.	1% Fat 5oz. S 2 dr. x 6	56	S	40.4
2	5 wks.	1% Fat 5oz. S 1 dr. x 6	57	F	29.0
3	3 mos.	1% Fat 4oz. S 1 dr. x 7	79	S	49.1
4	6 mos.	1% Fat 6oz. S 2 dr. x 6	68	S	44.8
5	9 mos.	Pept. Milk, 3 ozs. x 8	71	S	47.0
6	4 mos.	B.C.M. 5oz. S 1 dr. x 6	88	R	58.7
7	13 mos.	B.C.M. 7oz. S 1½ dr. x 5	42	S	42.4
8	10 mos.	B.C.M. 7oz. x 5	78	S	42.4
9	12 mos.	B.C.M. 7oz. S 1 dr. x 5	50	S	43.1
10	3 mos.	B.C.M. 2oz. x 2 hrly.	75	S	44.0
11	3 wks.	B.C.M. 3oz. S ½ dr. x 8	65	S	38.5
12	7 mos.	W.M. 6oz. S 1 dr. x 5	68	R	39.5
13	7 wks.	W.M. 3oz. S ½ dr. x 8	86	R	43.3
14	4 mos.	W.M. 4oz. S 1 dr. x 6	54	S	46.2
15	13 mos.	W.M. 7oz. S 1 dr. x 5	38	F	45.3
16	12 mos.	W.M. 6oz. S 1 dr. x 5	50	S	39.1
17	10 wks.	W.M. 4oz. S ½ dr. x 6	84	R	38.2
18	4½ mos.	W.M. 5oz. S 1 dr. x 5	78	S	45.9
19	9 mos.	W.M. 7oz. S 1 dr. x 5	71	S	43.8
20	6 mos.	W.M. 6oz. S 1 dr. x 5	75	R	45.4

fact that occasionally a fall in weight may be accompanied by a slight but definite rise in pulse and respiration rates.

From the above figures, one cannot conclude that there is any faulty metabolism of fats within the body. This portion of my investigation is, however, incomplete and, for the present, time will not permit me to complete it. To obtain more accurate results, it would be necessary to consider the alkaline reserve in relation to the blood volume and respiratory exchange.

6. SUMMARY AND CONCLUSIONS.

1. In infantile atrophy, rickets, and tetany, the digestion of fat is carried out as efficiently as in healthy children. There is therefore no loss of fat in these conditions from pancreatic insufficiency.

2. The fat output in the faeces varies directly with the dry faeces weight and forms approximately 1/3 of this.

3. Owing to this close relationship between fat output and the faeces weight, it is necessary in each and every balance experi-ment to take into consideration the faeces weight and, in order to determine whether the percentage absorption is normal or not, the observed result should be compared with the result calculated for the fat intake and faeces weight of the case under examination When this is done, the observed and calculated results in infant-ile atrophy are found to agree closely so that one can conclude that in this condition the percentage absorption of fat is not deficient.

The average percentage absorption of fat in atrophy is lower than in healthy infants but this is due to the much smaller intake of fat in this disease.

4. In infantile atrophy, the absolute excretion of fat is on an average 0.88 grams per day more than in health. This is due to the slightly larger motion passed but the excessive amount is so small that it may be neglected since it will in no way affect the nutrition of the child. There is no true deficient absorption since the average percentage of fat in the faeces is practically the same as in health.

Other facts point to a normal fat absorption in atrophy, viz. the increased amount of fat absorbed with an increase in the fat in-

-take and the clinical fact that improvement frequently follows the lowering of the fat content of the milk so that the condition is not due to a fat starvation.

5. In rickets, there is no deficiency in fat absorption. In abs-olute values, the increased loss of fat per day is only 0.66 grams more than in health. This is quite insufficient to affect nutri-tion. Here, also, the proportion of fat absorbed increases with increase in intake.

It has been shown from the study of rickets in Glasgow (23) that rachitic families have as great a fat intake as non-rachitic and there is no indication that the absence of the fat soluble growth producing factor played any important part in modifying the onset of the condition. From my own results, it is clear that in rickets fat absorption is normal so that fat starvation does not play any part in the causation of the condition.

6. In tetany, a condition closely associated with rickets, there is, on the average, a greater absolute loss of fat than in health, viz. 5.76 grams, so that the increased loss of fat was 2.46 grams. This is in part due to more bulky motions being passed and in part to a true deficient absorption. The excessive amount of fat lost is not enough to affect nutrition.

7. Saponification of fats in the stools is not associated with a defective absorption of fat. Insoluble soaps are present high up in the small intestine and the soaps and free fatty acids in the faeces vary in inverse relationship with one another.

8. From the constancy of the faeces fat in man and the lower animals, it is suggested that the faeces fat has a function to perform and that it is not a true excretion. This function may be of the nature of a bowel lubricant. Besides a certain amount

of fat in the faeces, it seems necessary to have a certain balance between the soaps and free fatty acids present in order to have a normal motion. It is suggested that this balance is necessary in order to prevent excessive retention of water in the bowel or an excessive absorption of water.

9. The alkaline reserve of the blood plasma in infantile atrophy appears from the cases examined to be slightly lower than that of health. A slight acidosis is present but this bears no relationship to the amount of fat ingested or to the nutritional state or trend of the infant. Further observations, however, on this point are necessary.

POSTSCRIPT

Since writing the above paper, an article by Holt, Courtney, and Fales on Fat Metabolism in Healthy Infants has appeared in the American Journal of Diseases of Children, Vol.17,vi, 1919. This paper gives results of the examination of the faeces which agree very closely with my own but no mention of faeces weight is made as a determining factor in the determination of fat absorption.

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CHART I.

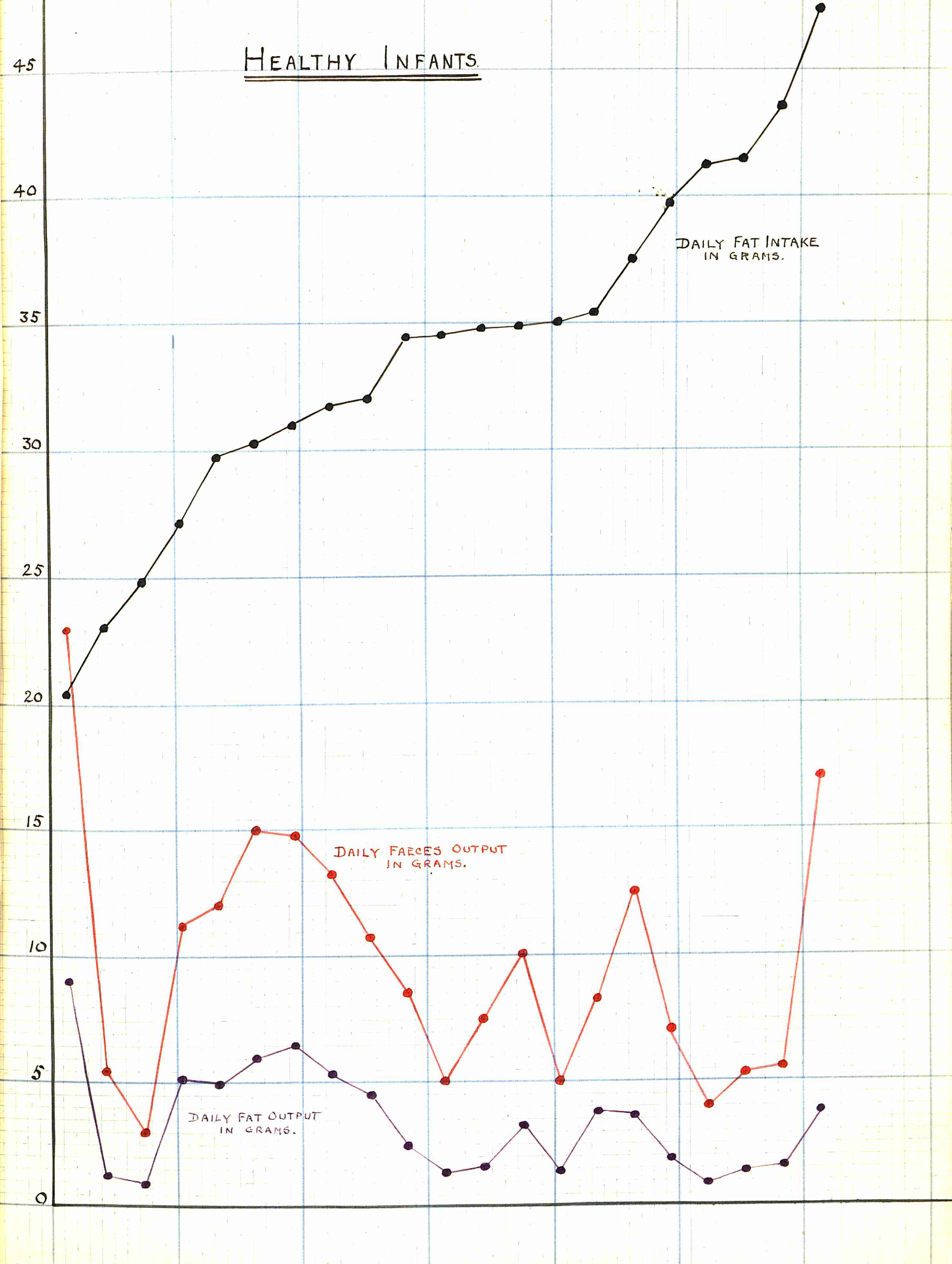

HEALTHY INFANTS
45
40
35
30
25
20
15
10
5
0
DAILY FAT INTAKE IN GRAMS.
DAILY FAECES OUTPUT IN GRAMS.
DAILY FAT OUTPUT IN GRAMS.

CHART 2.

INFANTILE ATROPHY.

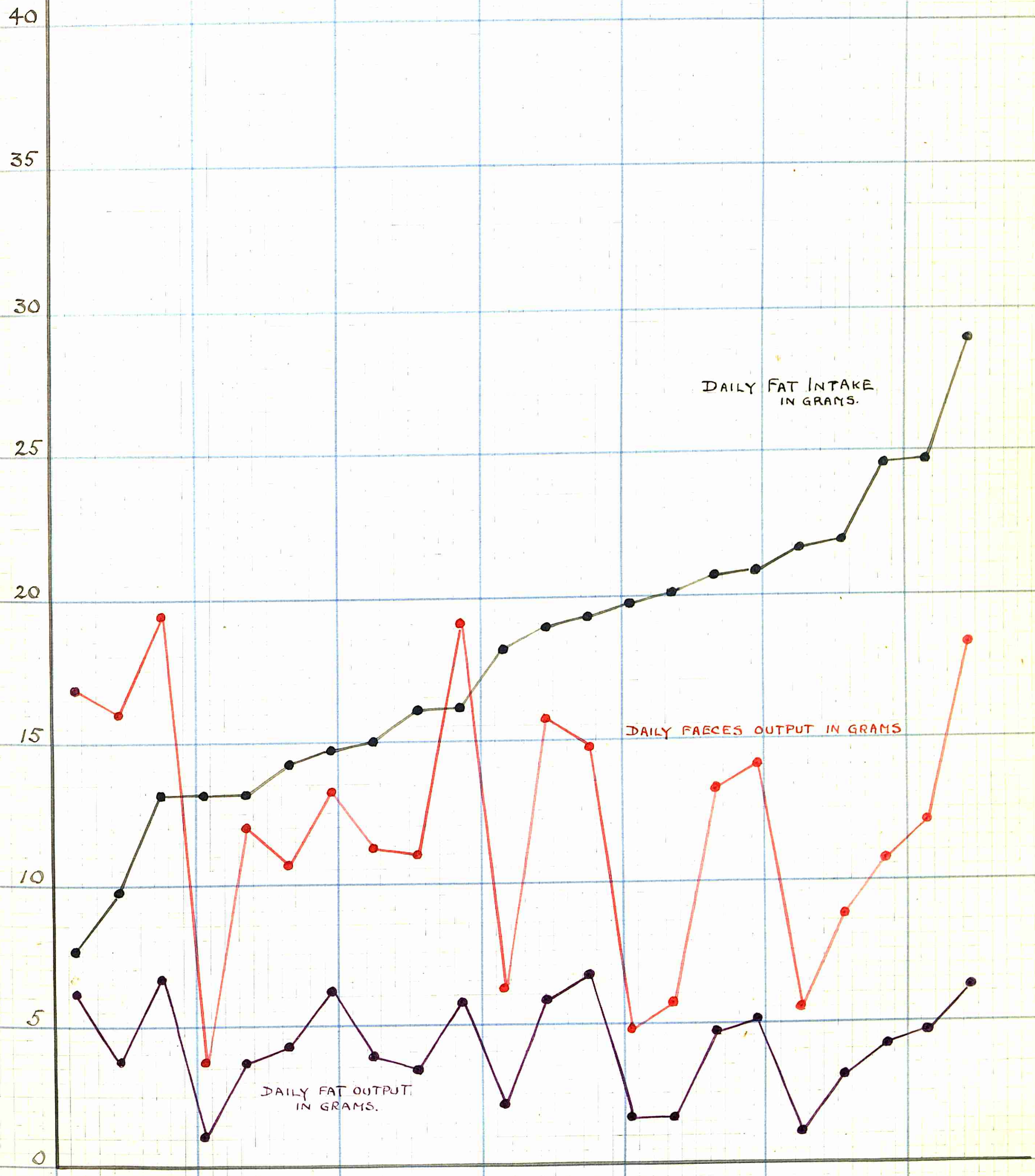


CHART 3.

RICKETS.

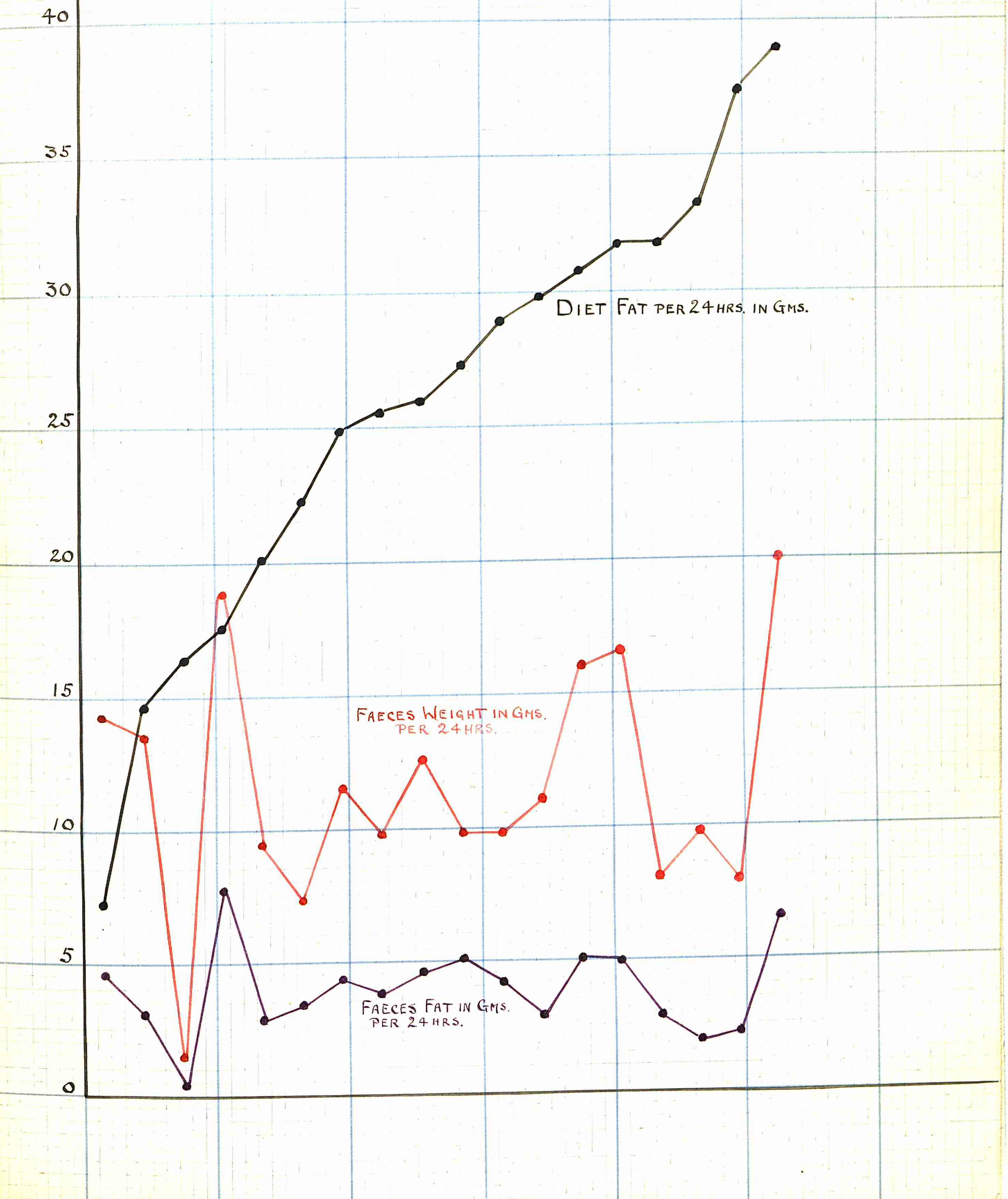


CHART 4.

TETANY

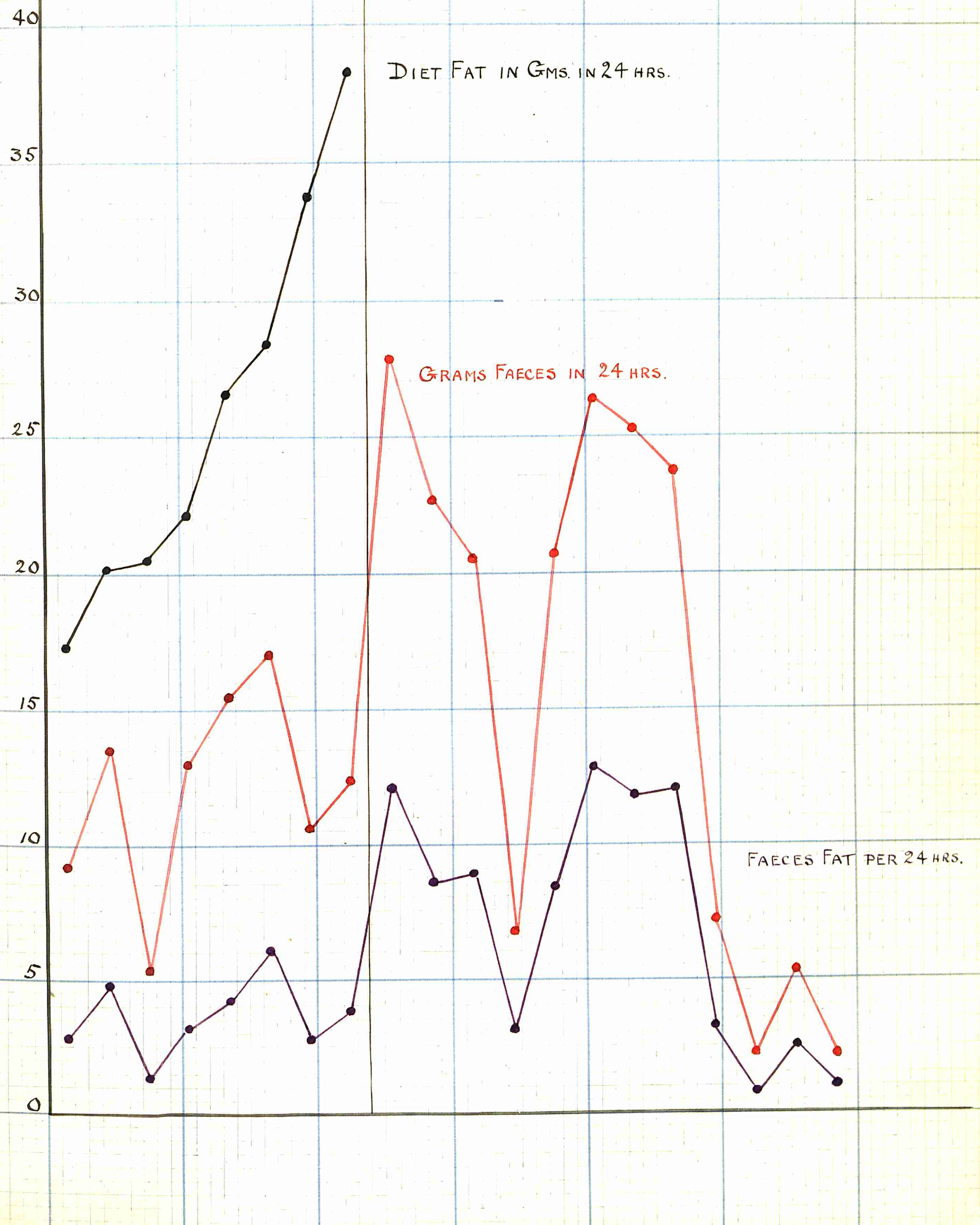


CHART 5.

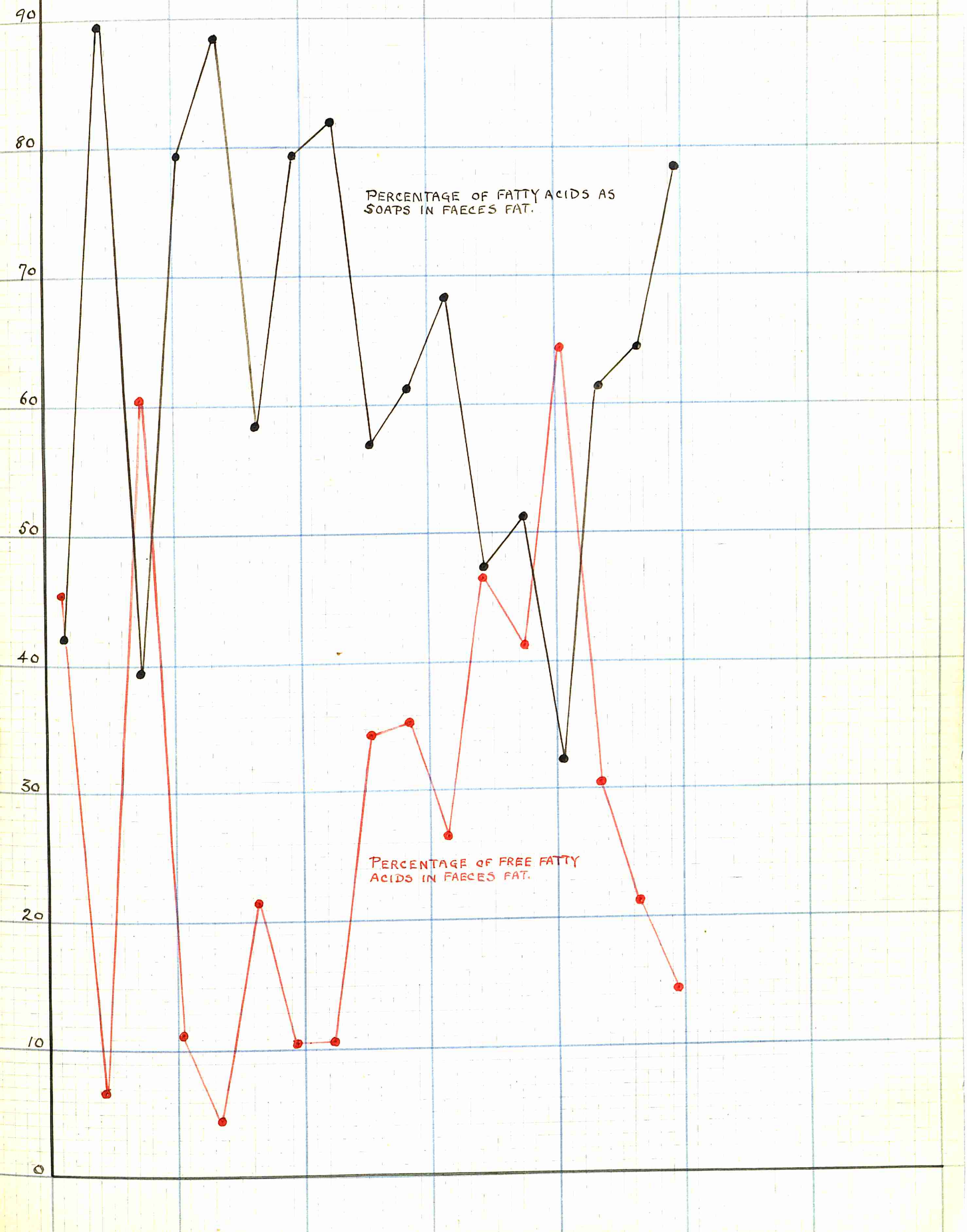
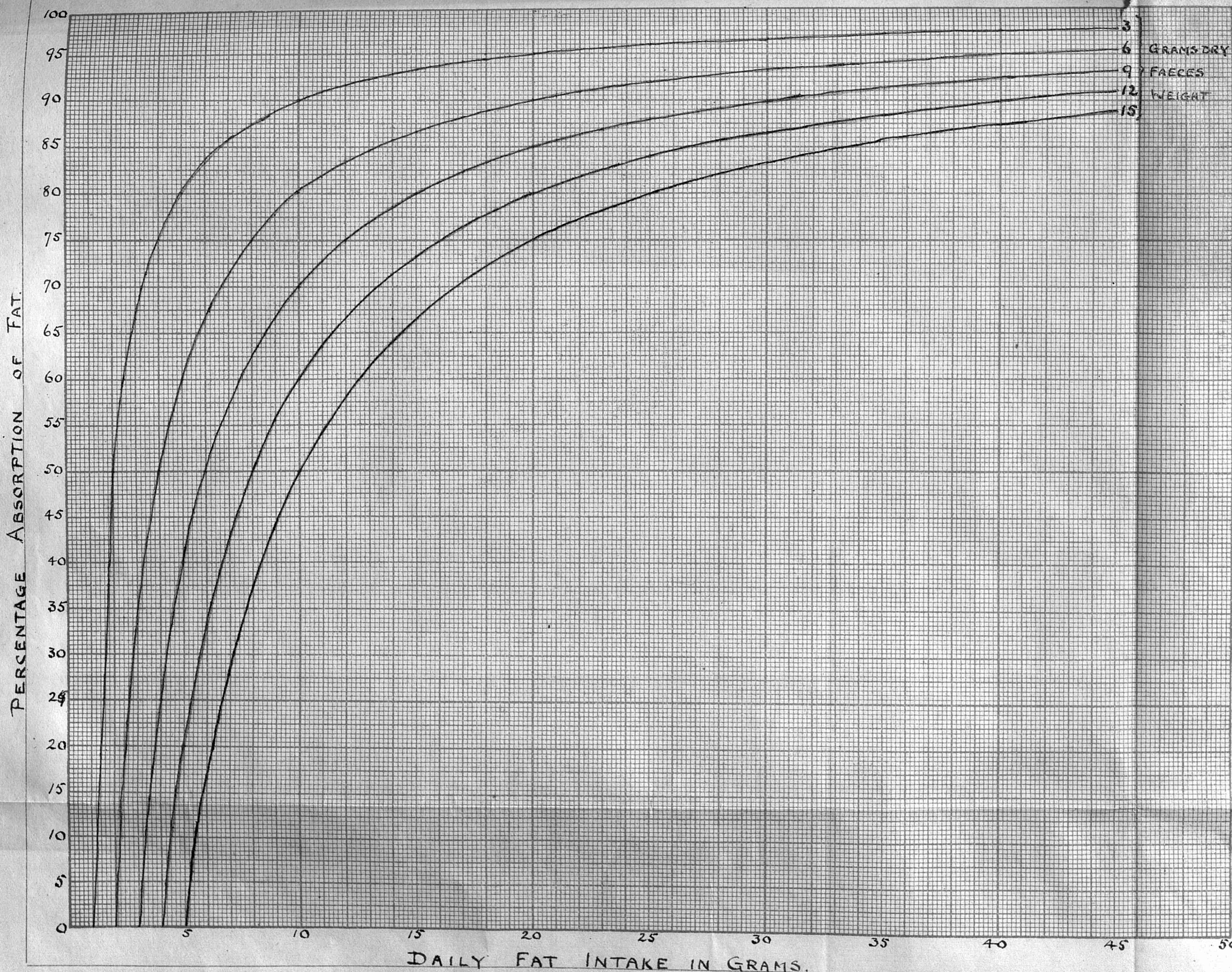

90
80
70
60
50
40
30
20
10
0
PERCENTAGE OF FATTY ACIDS AS SOAPS IN FAECES FAT.
PERCENTAGE OF FREE FATTY ACIDS IN FAECES FAT.

CHART 6.

CHART SHOWING AVERAGE PERCENTAGE ABSORPTIONS OF FAT WITH VARYING FAT INTAKE AND VARYING FAECES WEIGHTS.



FAT METABOLISM --- HEALTHY CONTROLS

No.	Daily intake of fat GMS.	Weight of dried faeces. GMS.	Fat retained GMS.	% of fat in dry faeces.	ABSOLUTE EXCRETION Total fat GMS.	Neutral fat GMS.	Fatty acids GMS.	Soap GMS.	PERCENTAGE EXCRETION % of fat absorbed	Neutral fat % of total fat	Fatty acid % of total fat	Soaps % of total fat
1	35.58	8.2	32.78	33.9	2.80	0.338	1.28	1.18	92.2	12.1	45.8	42.1
2	20.42	23.0	11.42	39.1	9.00	0.306	0.62	8.07	55.9	3.4	6.9	89.7
3	24.95	3.0	23.95	33.2	0.396	0.0006	0.60	0.39	96.4	0.06	60.4	39.5
4	27.21	11.2	22.05	46.0	5.16	0.459	0.583	4.11	81.0	8.9	11.3	79.8
5	23.04	5.4	21.72	24.5	1.32	0.091	0.227	1.00	94.3	6.9	4.4	88.7
6	34.62	5.0	33.25	27.5	1.37	0.06	0.13	1.18	96.0	4.4	9.5	86.1
7	34.83	10.0	31.62	32.1	3.21	0.20	0.18	2.82	90.7	6.2	5.8	88.0
8	41.34	4.0	40.41	23.3	0.932	0.044	0.103	0.78	97.7	4.7	11.1	84.2
9	63.2	14.8	59.53	24.8	3.67	0.164	0.315	3.19	94.1	4.7	8.5	86.8
10	34.83	7.5	33.17	22.2	1.659	0.112	0.097	1.45	95.2	6.7	5.8	87.5
11	41.47	5.3	40.09	26.0	1.378	0.088	0.075	1.21	96.6	6.4	5.5	88.1
12	47.47	17.1	43.58	22.8	3.89	0.256	0.222	3.42	91.8	6.5	5.7	87.8
13	39.75	7.1	37.94	24.1	1.81	0.12	0.149	1.54	95.4	7.0	8.7n	84.3
14	37.69	12.5	35.11	20.7	2.58	0.187	0.26	2.14	93.1	7.2	10.1	82.7
15	43.62	5.6	42.02	28.7	1.607	0.089	0.157	1.36	96.3	5.5	9.7	84.8
16	34.62	8.5	32.19	28.6	2.43	0.187	0.161	2.08	92.9	7.6	6.6	85.8
17	35.13	5.0	33.65	29.6	1.48	0.115	0.09	1.27	95.7	7.7	6.0	86.3
18	32.1	10.7	27.59	42.2	4.51	0.035	0.98	3.49	85.9	1.2	21.7	77.1
19	29.8	12.0	24.82	41.5	4.98	0.0	1.17	3.81	83.2	0.0	23.5	76.5
20	30.3	15.0	24.3	40.0	6.00	0.03	1.33	4.64	80.2	0.5	22.2	77.3
21	31.1	14.7	24.56	44.5	6.54	0.0	3.36	3.18	78.9	0.0	51.4	48.6
22	31.8	13.2	26.4	40.6	5.35	0.0	2.21	3.14	83.1	0.0	41.3	53.7
Av.	35.2 XXXXX	9.9	31.9	31.6	3.3	0.13	0.64	2.52	89.3	4.8	17.3	77.9

FAT METABOLISM. INFANTILE ATROPHY

					ABSOLUTE EXCRETION				PERCENTAGE EXCRETION			
No.	Daily intake of fat GMS.	Weight of dried faeces. GMS.	Fat retained GMS.	% of fat in dry faeces	Total fat GMS	Neutral fat GMS	Fatty acids GMS	Soaps GMS	% of fat absorbed	Neutral fat % of total fat	Fatty acid % of total fat	Soaps % of total fat
23	9.85	17.0	5.88	23.4	3.97	0.737	0.855	2.336	59.6	19.8	21.5	58.7
24	15.07	11.2	11.29	33.8	3.78	0.389	0.389	3.002	74.8	10.3	10.3	79.4
25	20.11	5.8	18.54	30.8	1.57				92.3			
26	13.10	3.7	12.07	27.9	1.03	0.074	0.11	0.846	92.2	7.2	10.7	82.1
27	16.07	11.0	12.62	31.4	3.45	0.279	1.204	1.967	78.5	8.1	34.9	57.0
28	13.10	12.0	9.37	31.1	3.73	0.093	1.339	2.3	71.5	2.5	35.9	61.6
29	28.71	18.2	22.3	35.2	6.41	0.327	1.705	4.378	78.0	5.1	26.6	68.3
30	24.58	10.7	20.53	38.8	4.05				83.8			
31	24.58	12.1	20.02	37.7	4.56				81.5			
32	18.18	6.25	15.93	36.0	2.25				87.7			
33	16.23	19.0	10.49	30.2	5.74	0.275	2.72	2.74	64.6	4.8	47.4	47.8
34	19.83	4.7	18.19	34.9	1.64	0.118	0.68	0.842	91.7	7.2	41.5	51.3
35	21.63	4.5	20.44	26.5	1.19	0.034	0.767	0.389	94.4	2.9	64.5	32.6
36	18.91	15.6	13.31	35.9	5.6	0.722	1.69	3.188	70.4	8.4	30.2	61.4
37	20.44	13.1	15.73	36.0	4.71	0.692	0.993	3.025	76.8	14.7	21.1	64.2
38	20.44	14.15	15.06	38.0	5.38	0.371	0.769	4.24	73.7	6.9	14.3	78.8
39	14.23	10.6	9.88	41.0	4.35	0.0	1.93	2.42	69.4	0.0	44.5	55.5
40	13.2	19.4	6.53	34.4	6.67	0.19	3.62	2.86	49.4	2.9	54.3	42.8
41	7.62	16.9	1.49	36.3	6.13	0.0	3.44	2.69	19.5	0.0	56.1	43.9
42	21.96	3.7	18.95	34.6	3.01	0.005	0.478	2.527	86.3	0.19	15.9	83.9
43	19.28	14.7	12.68	44.9	6.6	1.88	0.74	3.98	65.7	28.6	11.2	60.2
44	14.70	13.25	8.37	47.8	6.33	1.04	2.14	3.15	56.9	16.5	33.8	49.7
Av.	17.8	11.9	13.6	34.8	4.18	0.404	1.42	2.82	73.5	8.1	31.8	60.1

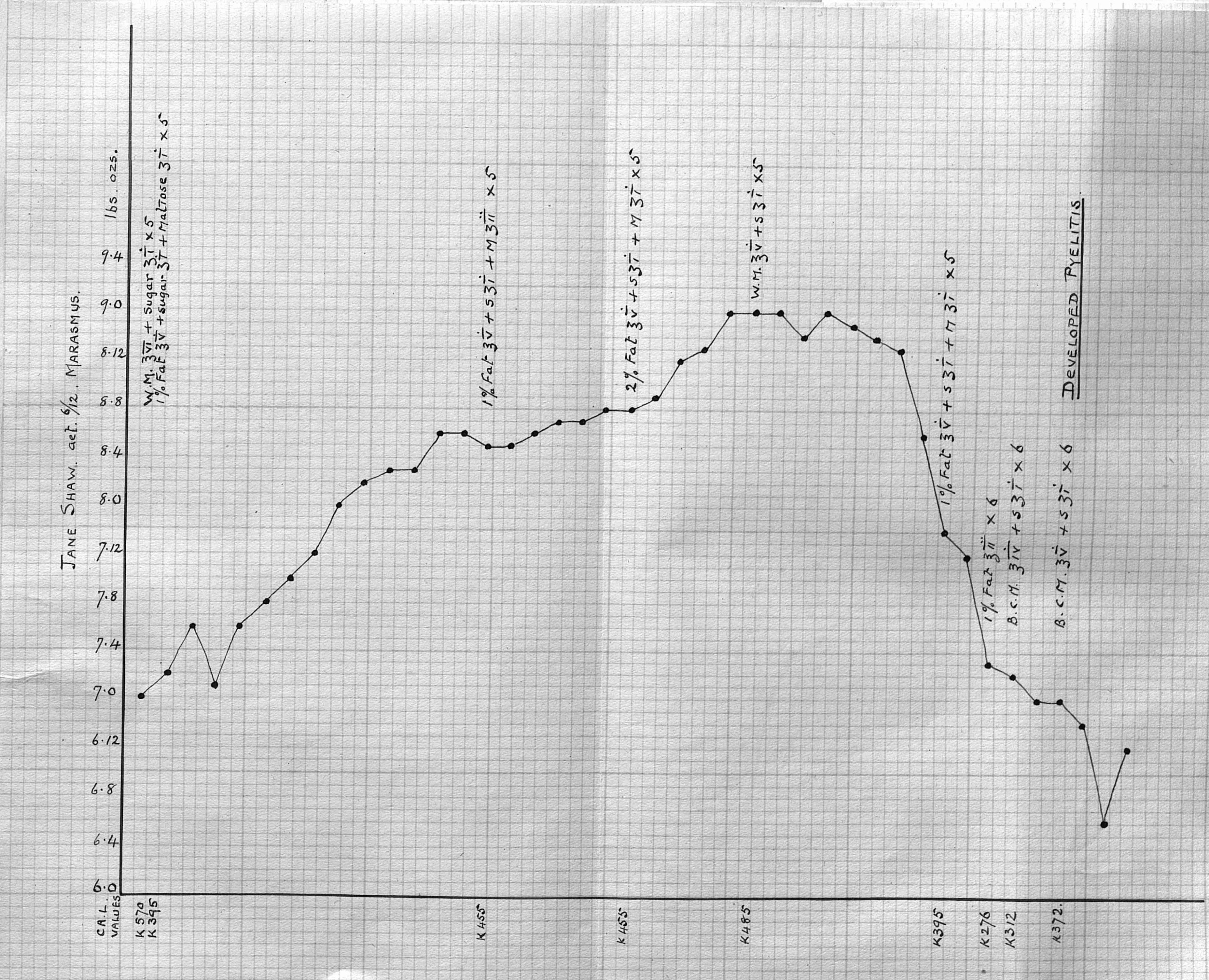
FAT METABOLISM. RICKETS

					ABSOLUTE EXCRETION				PERCENTAGE EXCRETION			
No.	Daily intake of fat GMS	Weight of dried faeces GMS	Fat retained GMS	% of fat in dry faeces	Total fat GMS	Neutral fat GMS	Fatty acids GMS	Soaps GMS	% of fat absorbed	Neutral fat % of total fat	Fatty acid % of total fat	Soaps % of total fat
45	25.95	12.5	21.43	36.0	4.52	0.174	1.104	3.24	82.6	3.85	24.4	72.1
46	22.26	7.3	18.84	46.9	3.42	0.477	0.442	2.50	84.7	13.9	12.9	73.2
47	38.92	20.0	32.42	32.5	6.50	0.046	3.534	2.92	83.3	0.8	54.3	44.9
48	37.41	7.9	35.21	27.8	2.20	0.152	1.435	0.61	94.1	6.9	65.3	27.8
49	20.19	9.4	17.26	31.2	2.93	0.542	1.347	1.04	85.4	18.4	45.9	35.7
50	24.93	11.5	20.60	37.7	4.33	0.000	2.208	2.12	32.6	0.00	50.9	49.1
51	30.71	16.0	25.63	36.3	5.08	0.000	2.160	2.92	83.4	0.00	37.1	62.9
52	31.74	16.5	26.75	30.3	4.99	0.0000	2.508	2.48	84.2	0.00	50.1	49.9
53	29.81	11.0	26.85	26.9	2.96	0.000	1.782	1.17	90.0	0.00	60.2	39.8
54	31.49	8.0	28.64	35.7	2.35	0.000	1.320	1.53	90.0	0.00	46.2	53.8
55	7.26	14.2	2.73	32.2	4.53				37.6			
56	14.62	13.5	11.51	23.2	3.11				78.7			
57	16.47	1.5	15.99	32.2	0.48				97.0			
58	17.55	18.7	9.85	41.6	7.7				56.1			
59	25.56	9.75	21.79	38.7	3.77	0.173	0.573	3.02	85.2	4.6	15.2	80.2
60	27.27	9.75	22.12	52.9	5.15	0.000	1.44	3.71	81.1	0.0	28.1	71.9
61	33.21	9.75	31.40	18.6	1.81	0.083	0.722	1.00	94.5	4.6	39.9	55.5
62	28.95	9.75	24.77	42.9	4.18	0.100	2.40	1.68	89.0	2.4	57.5	40.1
Av.	25.79	11.5	21.87	34.6	3.91	0.124	1.54	2.14	82.2	3.9	42.0	54.1

FAT METABOLISM. TETANY

No.	Daily intake of fat GMS	Weight of dried faeces GMS	Fat retained GMS	% of fat in dry faeces	ABSOLUTE EXCRETION Total fat GMS	Neutral fat GMS	Fatty acids GMS	Soaps GMS	PERCENTAGE EXCRETION % of fat absorbed	Neutral fat % of total fat	Fatty acid % of total fat	Soaps % of total fat
63	28.4	17.0	22.27	36.0	6.13	0.536	0.652	4.89	78.4	9.5	10.6	79.9
64	17.31	9.1	14.39	32.0	2.92	0.305	0.537	2.07	83.1	10.4	18.4	71.2
65	22.10	13.0	18.85	25.0	3.25	0.40	0.76	2.08	85.2	12.4	23.6	64.0
66	20.50	5.4	19.02	27.5	1.48	0.20	0.19	1.08	92.7	13.7	13.1	73.2
67	26.55	15.5	22.34	27.2	4.21	0.10	1.31	2.79	84.2	2.5	31.2	66.3
68	20.10	13.5	15.20	36.3	4.90	0.00	1.87	3.03	75.6	0.0	38.2	61.8
69	33.7	10.7	30.82	27.0	2.88	0.25	0.43	2.19	91.4	8.9	15.1	76.0
70	38.34	12.4	34.49	31.1	3.85	0.20	0.37	3.27	89.9	5.3	9.8	84.9
71	-	27.8	-	43.5	12.08	1.69	3.19	7.20	-	14.0	41.3	44.7
72	-	22.6	-	37.7	8.52	0.72	4.93	2.87	-	8.4	57.8	33.8
73	-	20.5	-	43.8	8.97	0.313	2.57	6.08	-	3.4	28.6	68.0
74	-	6.8	-	46.5	3.15	0.096	0.78	2.28	-	3.0	24.6	72.4
75	-	20.7	-	40.8	8.44	0.37	3.58	4.49	-	4.3	42.4	53.3
76	-	26.4	-	49.1	12.95	0.184	5.38	7.39	-	1.5	41.5	57.0
77	-	25.2	-	47.0	11.84	0.00	4.81	7.03	-	0.0	40.6	59.4
78	-	23.7	-	51.0	12.08	0.00	2.89	9.19	-	0.0	23.9	76.1
79	-	7.1	-	45.6	3.23							
80	-	2.3	-	36.8	0.84							
81	-	6.3	-	40.0	2.52							
82	-	2.2	-	49.2	1.08							
Av.	25.8	14.4	22.1	38.0	5.76	0.33	2.15	4.24	85.0	6.08	29.4	65.1

BIWEEKLY WEIGHT CHARTS.



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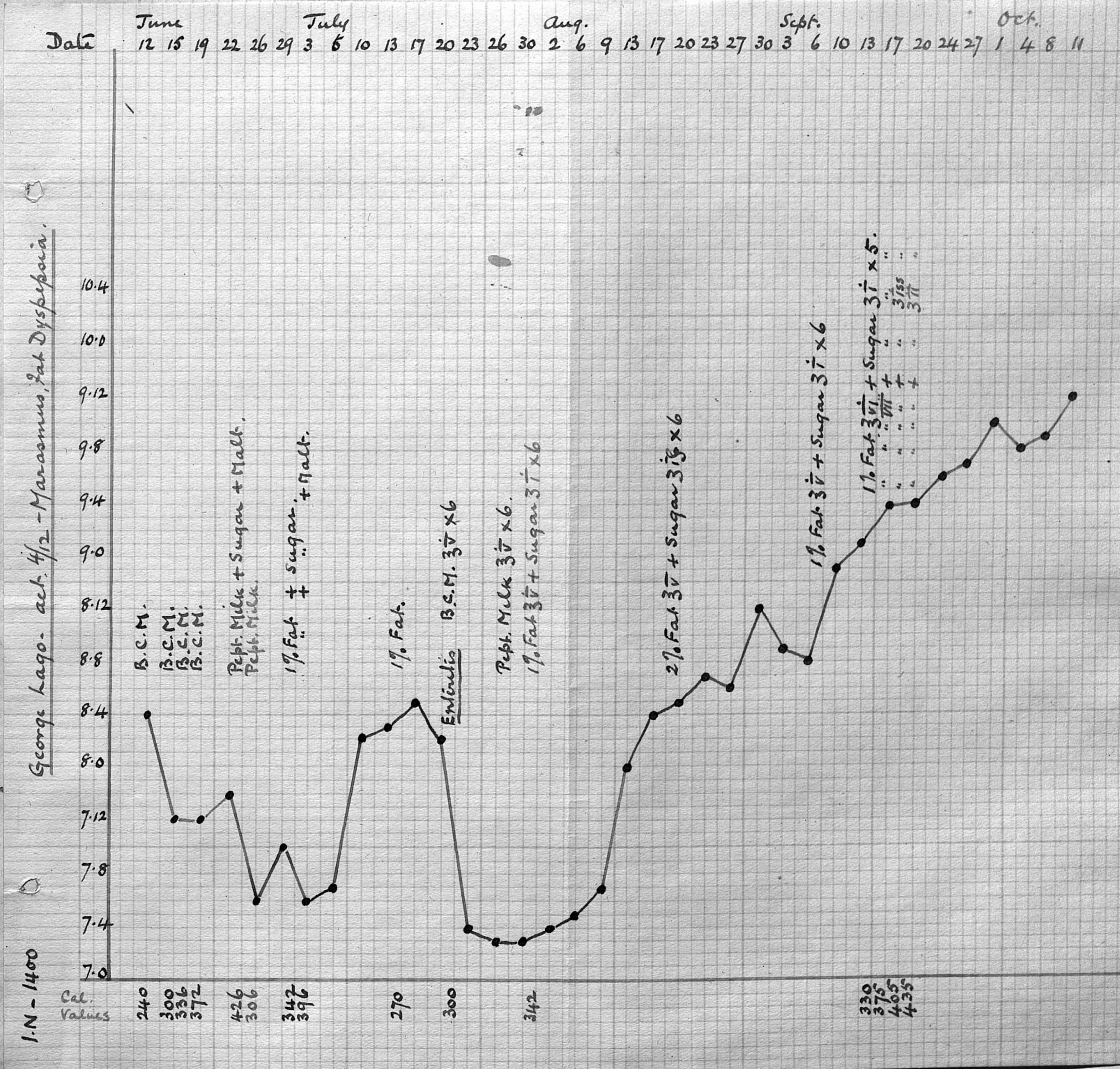

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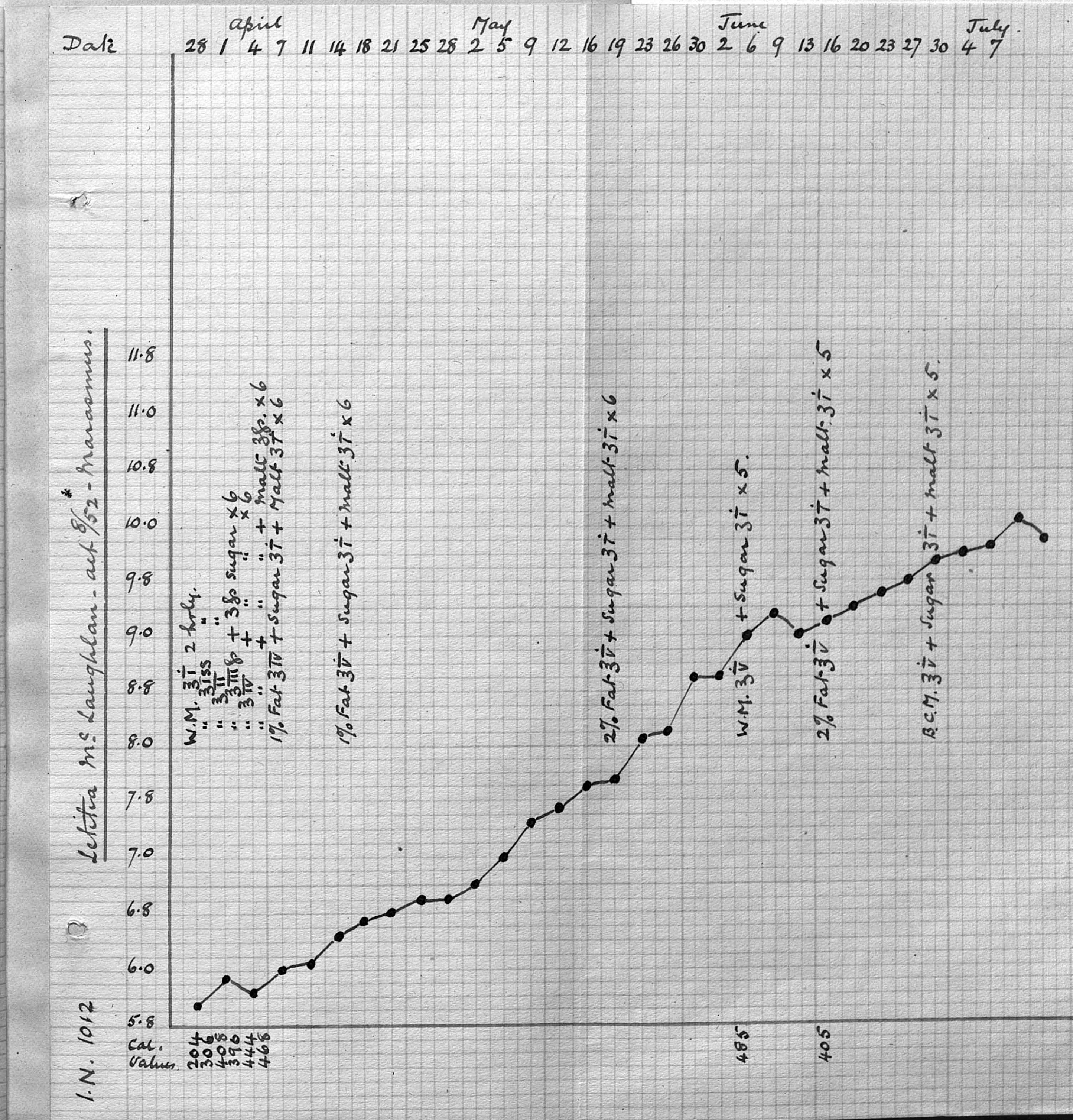
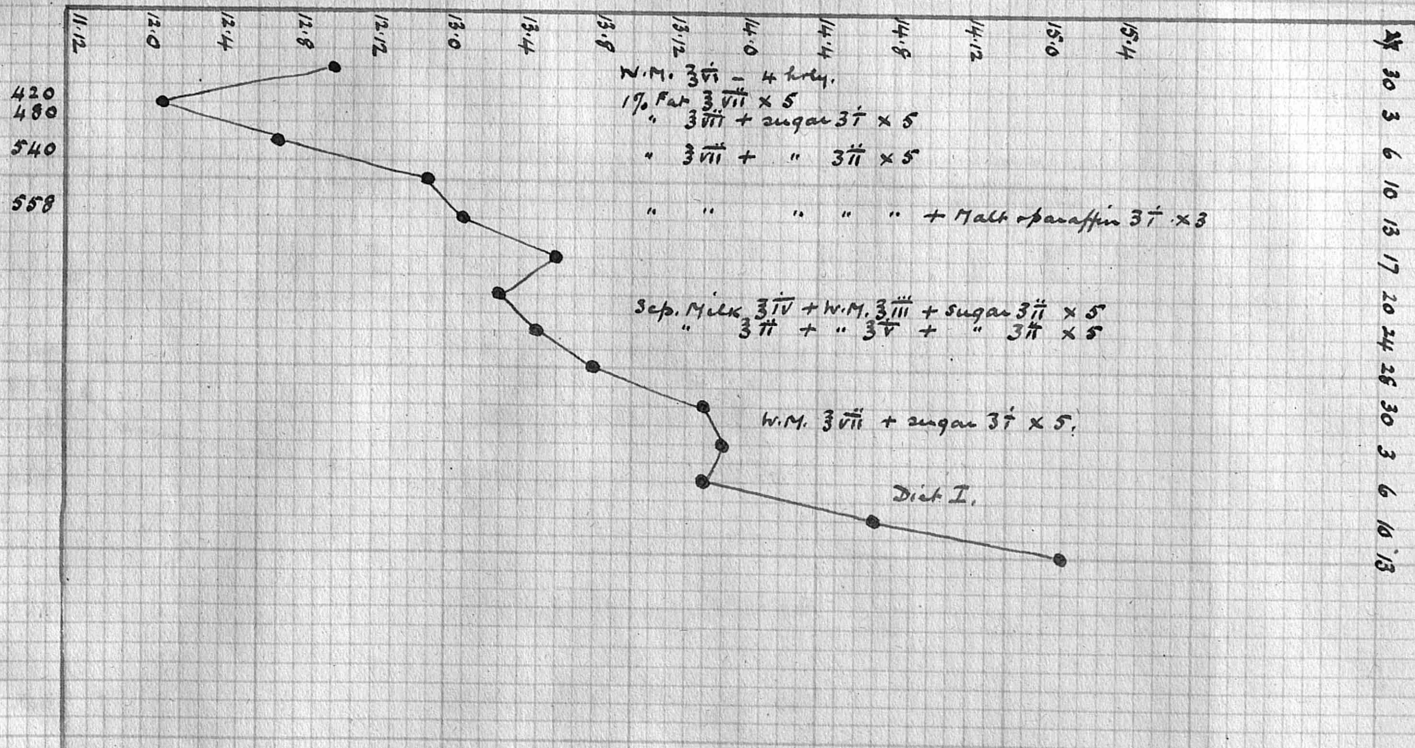
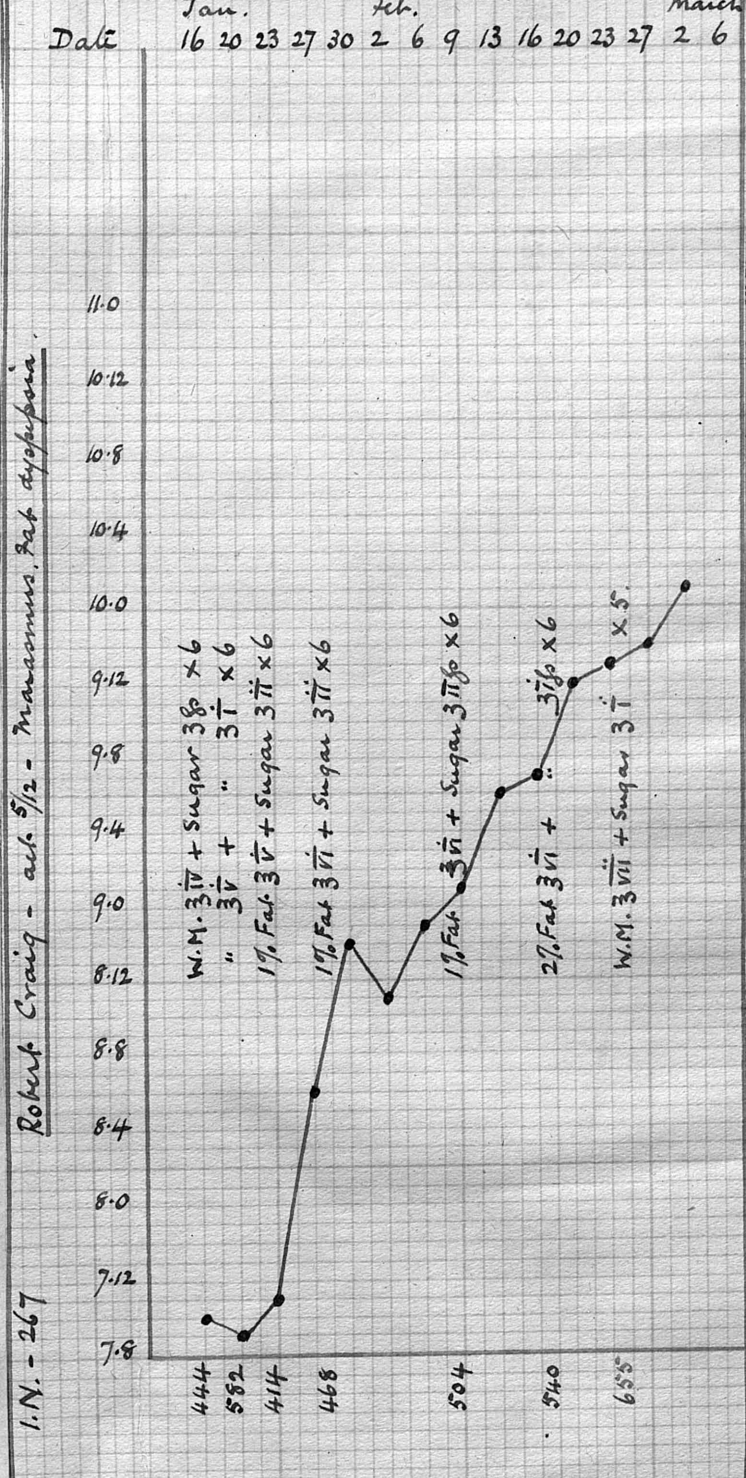


I.N. 26/57

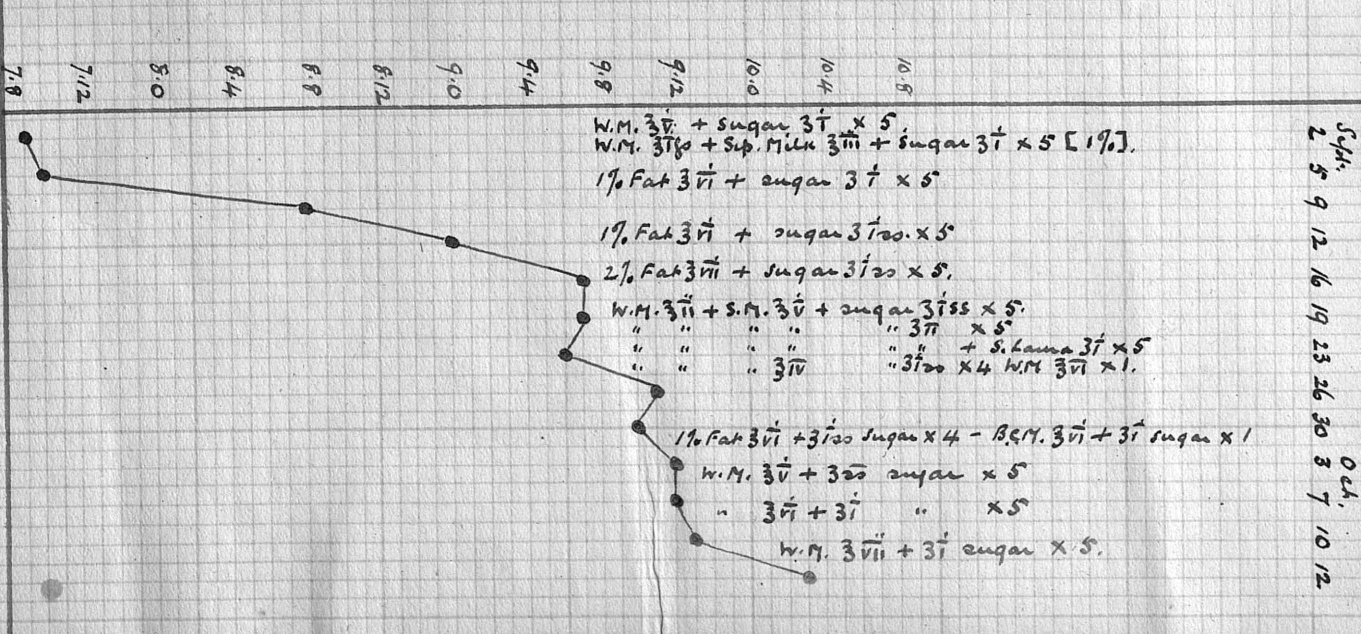
Alex. Murdoch. – aet 1 6/12 – Marasmus.




I.N. - 267
Robert Craig - aet. 5/12 - Marasmus, Fat dyspepsia
Date
Jan.
16 20 23 27 30
Feb.
2 6 9 13 16 20 23 27
March
2 6
11.0
10.12
10.8
10.4
10.0
9.12
9.8
9.4
9.0
8.12
8.8
8.4
8.0
7.12
7.8
W.M. ℥iv + Sugar ʒss × 6
" ℥v + " ʒi × 6
1% Fat ℥v + Sugar ʒii × 6
1% Fat ℥vi + Sugar ʒii × 6
1% Fat ℥vi + Sugar ʒiiss × 6
2% Fat ℥vi + " ʒiss × 6
W.M. ℥vii + Sugar ʒi × 5
444
582
414
468
504
540
655

I.N. 26/65

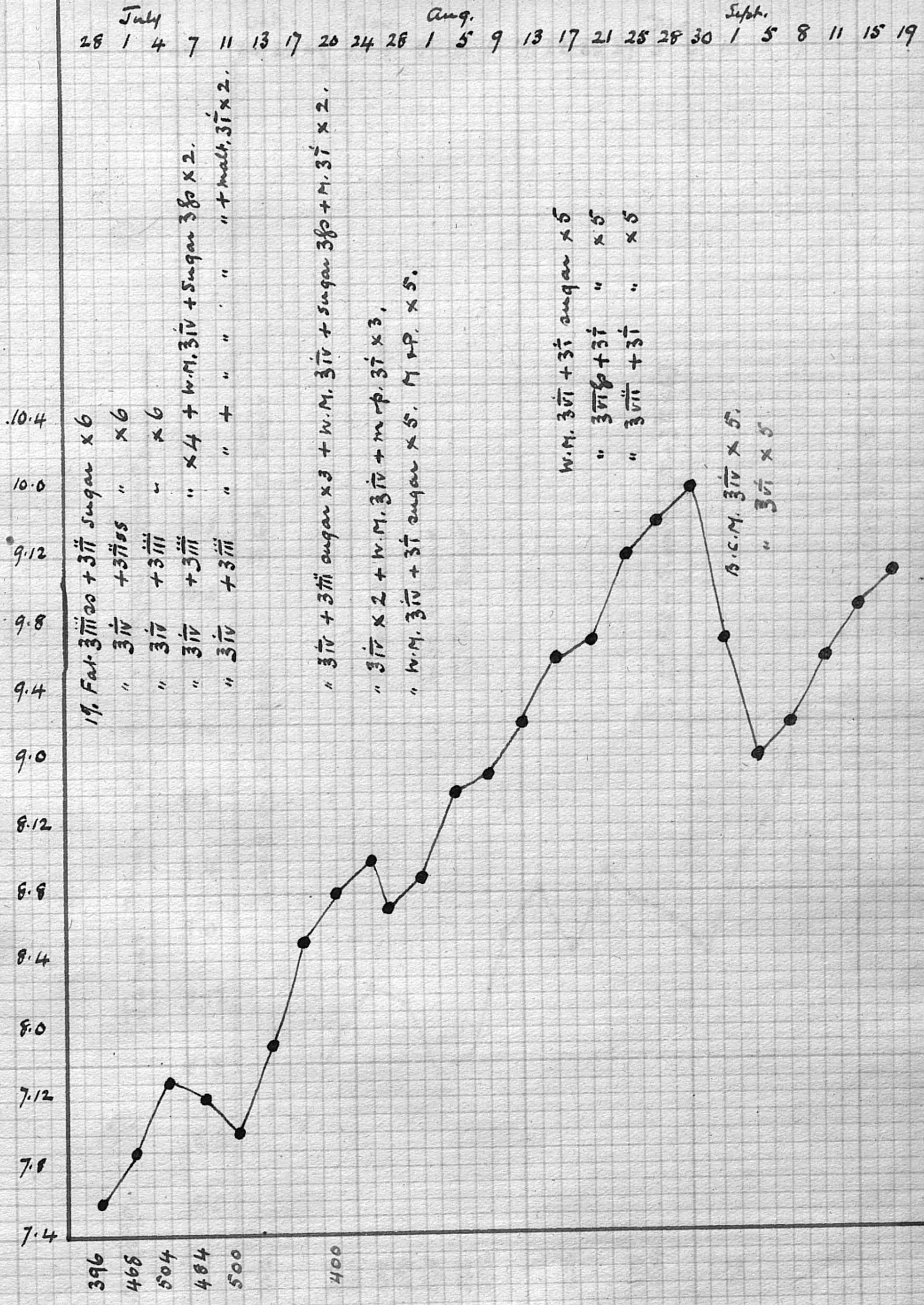
Catherine Kerr - aet 6/12 - Marasmus.



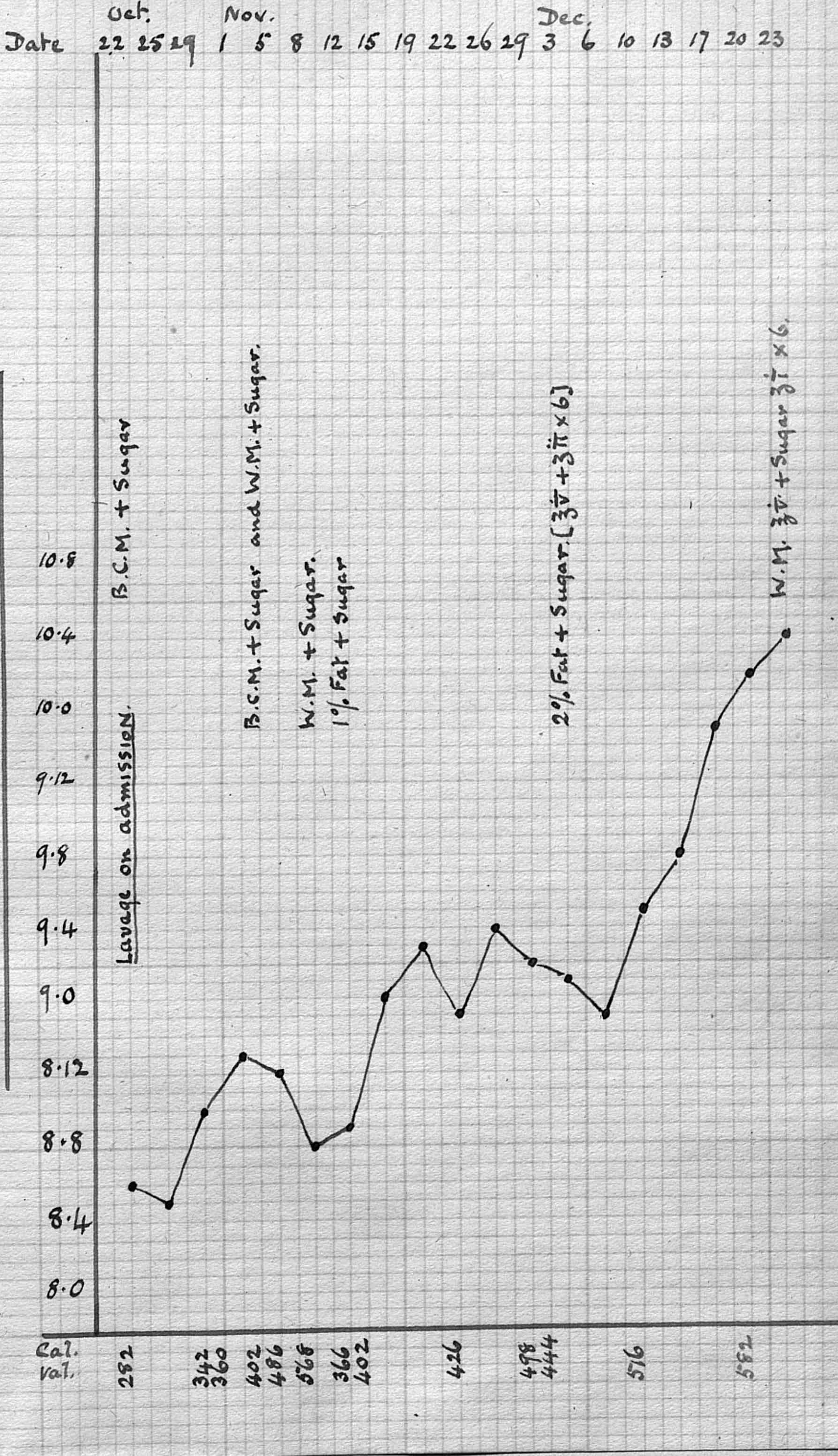
NORMAN GILES - AGED 6 MONTHS - ATROPHY.

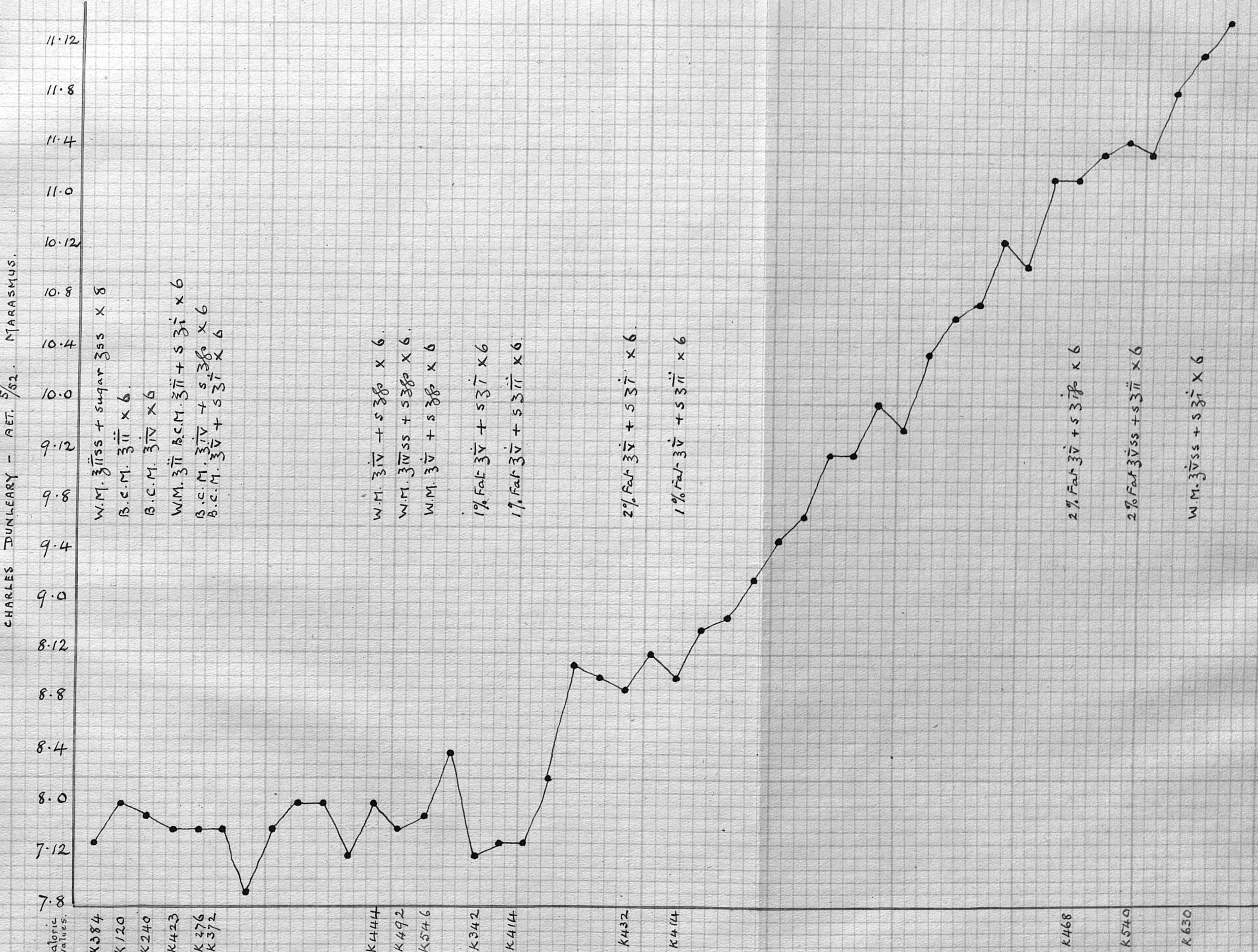
I.N. 26/56

Murdoch McIver – aet 2/12 – Marasmus



I.A. 1690. James Brown - aet 4/12 - Marasmus.




CHARLES DUNLEARY – AET. 5/52. MARASMUS.
11·12
11·8
11·4
11·0
10·12
10·8
10·4
10·0
9·12
9·8
9·4
9·0
8·12
8·8
8·4
8·0
7·12
7·8
Caloric values.
K384
K120
K240
K423
K276
K372
K444
K492
K546
K342
K414
K432
K414
K468
K540
K630
W.M. ℥iiss + sugar ℥ss × 8
B.C.M. ℥ii × 6
B.C.M. ℥iv × 6
W.M. ℥ii B.C.M. ℥ii + s ℥i × 6
B.C.M. ℥iv + s ʒss × 6
B.C.M. ℥v + s ℥i × 6
W.M. ℥iv + s ʒss × 6.
W.M. ℥ivss + s ʒss × 6.
W.M. ℥v + s ʒss × 6
1% Fat ℥v + s ℥i × 6
1% Fat ℥v + s ℥ii × 6.
2% Fat ℥v + s ℥i × 6.
1% Fat ℥v + s ℥ii × 6
2% Fat ℥v + s ℥iss × 6
2% Fat ℥vss + s ℥ii × 6
W.M. ℥vss + s ℥i × 6