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Effects of Variations in the Amounts of Vitamin B and Protein in the Ration

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ABSTRACT

A comparison has been made of the growth rate of rats which received rations that varied in the content of vitamin B (complex) and of protein. One group received a ration deficient in both vitamin B and protein; a second received this same ration with an additional allowance of vitamin B; a third received a similar ration except it contained a much larger percentage of protein; the fourth received the high protein ration and the vitamin B supplement in addition. Two methods of feeding were used, *ad libitum* and regulated.

When the *ad libitum* method was used the following observations were made: If the basal diet is supplemented with vitamin B the food intake is increased. If the protein content of the basal ration is raised to a higher level the food intake is practically unchanged. In both cases the rate of growth is accelerated. When these two changes are made simultaneously the food intake is greatly augmented, and the rate of growth is still more rapid.

When the regulated method of feeding was used the following observations were made: The addition of vitamin B to either the low or high protein ration accelerates the growth rate slightly, but the acceleration may be ascribed to the calorific value of the supplement. When the percentage of protein in the ration is increased, the rate of growth increases also.

Within the limits of the protein levels used, convincing evidence was not obtained that the amount of vitamin B necessary for a certain rate of growth varies with the quantity of protein in the diet. The corollary conclusion is, the amount of protein necessary for a certain rate of growth does not vary with the amount of vitamin B supplied.

If a ration is deficient in both protein and vitamin B, it is made more adequate for growth by increasing the amount singly of either constituent.

Effects of Variations in the Amounts of Vitamin B and Protein in the Ration

ALBERT G. HOGAN AND ROBERT W. PILCHER

HISTORICAL

Ever since the recognition of vitamin B as an essential nutrient there has been continuous interest in determining the amount required to completely supplement rations that are otherwise adequate. The results of such investigations have led to the belief among many workers that the minimum daily requirement may be variable, depending on the proportions of certain other nutrients in the diet. Practically ever since the vitamin was discovered, there has been a more or less continuous discussion of the possibility that the requirement for vitamin B may increase as the level of carbohydrate intake rises. More recently it has been asserted that the requirement for this vitamin may also be increased by a rise in the protein intake, and this view is commonly accepted today. If this acceptance is justified it may have important practical consequences. In the stage of rapid growth animals commonly consume rations of a high protein content, and it is during this stage that producers of livestock, of swine and poultry especially, are likely to meet unexpected difficulties.

The literature in this field is very extensive, and because of the limitations of space only those papers will be reviewed that have a direct application to our problem. The monographs of Sherman and Smith[1], and of the British Medical Research Council[2] may be consulted for additional references. Our interest at present is limited to the possible interrelation between the amounts of protein and vitamin B in the diet. As a result of her studies on the effect of diet on lactation Hartwell[3] expressed the opinion that more vitamin B is required when the allowance of protein is liberal than when it is at a moderate level. Drummond and collaborators made somewhat similar studies of the possible quantitative relation between protein and vitamin B, but used growing rats as experimental animals. Their results confirmed those of Hartwell. Drummond, Crowden and Hill[4] used two rations, one containing 20, the other 83% of casein. The two rations contained the same percentage of yeast extract, as a source of vitamin B. The lower percentage of casein permitted growth to normal adult size, but the higher level sustained growth only to about 150 grams. A few years later Reader and Drummond[5] published the results of similar studies. They reported that on rations containing 45% casein, rats grew normally for 8 or 10 weeks, but made only slight gains thereafter. If the casein were increased to 90% the adult size was only one-third of the normal. Reader and Drummond[6] later suggested that in order for normal growth to occur the ratio of yeast to vitamin B must not fall below a definite minimum. They stated that there should be not less than 1 part of yeast extract to 5 parts of protein. Some of Hartwell's conclusions[7] are in fair agreement with this estimate. She observed growing rats, and used rations containing 20% of protein. She stated that growth was subnormal unless the rations contained a minimum of about 5% of marmite.

In investigations of the type we have been describing there may be a difference of opinion as to the most suitable procedure, but there is no doubt that this may be an important factor in determining the outcome of a series of observations. One important suggestion now commonly adopted is the Steenbock technique[8] for the prevention of coprophagy. The importance of this point can not be determined without specific study, but it may be significant that the Steenbock procedure to prevent coprophagy was not used by the workers just mentioned. It was used by Sherman and Gloy[9], and these investigators obtained no evidence that the requirement for vitamin B may be affected by the amount of protein consumed. The percentage of protein in their rations varied from 12 to 54, and orange juice was used as a source of the vitamin. It may be significant that the general condition of the rats when they received 18% of casein was better than when they were on the higher levels. The experimental periods only covered 8 weeks, however, so the significance of that observation is uncertain.

Another point of procedure which has been much studied recently in feeding trials is the method of feeding the experimental animals. The *ad libitum* method is most used at present, but it has been severely criticised by Mitchell[10 a b], who regards it, and the results it gives, as indecisive at best. He insists one cannot escape the obvious fact that the extent of growth is chiefly dependent on the amount of food eaten. Rose[11] does not altogether agree with Mitchell, and stresses the fact that a diminished food intake is a direct result of dietary inadequacy. In his support he cites such authorities as F. G. Hopkins, and Osborne and Mendel. His position seems to imply that under controlled conditions the failure to consume food may be as significant as the gains in weight.

One of the first attempts at avoiding the uncertanties of the *ad libitum* method is that of Osborne and Mendel[12]. They were investigating the relative efficiency of various proteins, and initiated the limited feeding method. According to this procedure all experimental animals receive the same amount of food, and of protein, per unit body weight. This technique was later changed[13] to what they designated as their Series A and Series B types of feeding. In the Series A type the animals are given increasing amounts of the experimental diets at definite time intervals regardless of their body weights. In the Series B type, which was preferred by the authors, the animals compared are given the same amount of food, and the composition of the rations is so regulated that they make the same gains in weight in the same interval of time.

A method that is somewhat simpler in practice, but which contains the essential features of the procedure of Osborne and Mendel was first proposed by Armsby[14], and was later used by Gulick[15]. More recently it has found an exponent in Mitchell[10b] and it is largely due to him that this procedure, known as the paired-feeding method, is now being widely used in various laboratories. In this method the animals on the control and experimental diets are arranged in pairs, and the intake of both animals of any one pair is the same. The amount of food offered the animal which would voluntarily eat the most, is limited to the quantity consumed by the other member of the pair. Mitchell's chief point is that even though the animals on the better ration are restricted as to intake, they will still do better than those on the poorer ration, which are eating *ad libitum.*

In planning the work to be described later it was decided to use both the paired feeding and *ad libitum* methods, and compare the results obtained by the two procedures. In this paper the paired feeding method has been designated the regulated method, inasmuch as four animals instead of two were maintained on the same intake.

It is unnecessary at present to review the extensive literature in which the paired feeding method has been used, but there are a few papers which have a direct application to the data to be present-ed later. In the course of his studies on the deficiencies of synthetic diets Hopkins[16] noted that young rats were able to grow if the basal diet was supplemented with small quantities of milk, and calculated that the increased growth rate was not the result of an increased supply of calories. He also observed that when rats received inadequate diets, the rate of growth decreased before the food intake was diminished. This observation is now interpreted as showing that a ration deficient in vitamins supports less rapid growth than one that is more nearly complete, even though the energy intake be identical. In a brief abstract Mitchell[17] supports this point of view, in a statement that the paired-feeding method may be successfully applied to the determination of vitamin B. Sure[18] seems to be in complete agreement with Mitchell. Palmer's observations[19] have some application to this point, though it was not his immediate problem. His data indicate that if animals consume the same amount of energy, their rates of growth will not be much affected by differences in the amount of vitamin consumed.

Mitchell[17] also states that when a ration contain 18% of casein, between 40 and 45% of corn is required to provide enough vitamin B, but if the ration contains 30% of casein, then adequate vitamin B is supplied by from 25 to 30% corn. This does not agree with the experience of Sherman and Gloy[9] who noted no difference in the vitamin B requirement within these limits. Also, it does not agree with the results of Drummond and coworkers[4 5 6], who observed an increased requirement for vitamin B as the quantity of protein was increased.

Our primary purpose was a reinvestigation of some of these disputed points, especially of the following: (1) Does the amount of either protein or of vitamin B that is necessary for a certain rate of growth, vary according to the quantity that is supplied of the other constituent. In addition the following possibilities were also considered. (2) If a ration is deficient in both protein and vitamin B, is it made more adequate for growth by increasing singly the amount of either one. It should be pointed out that if such an increase in adequacy were observed, it might be an illustration of a more general law. That is, when a ration is deficient in any two respects, growth is accelerated by increasing the amount of either one.

EXPERIMENTAL

Procedure.—Albino rats were used exclusively and were confined in individual metal cages, with floors of hardware cloth. The food containers were made especially for this work, and were designed to reduce to a minimum the wastage of food and to facilitate an accurate determination of the amount of food consumed. Water was supplied in an inverted drinking fountain.

The food was weighed out on a small agate-bearing beam balance, to an accuracy of about 10 milligrams, and transferred to the food containers. The cages were placed over 10-inch filter papers, in graniteware pans, so wasted food could be recovered. On the following day the food in the box and that spilled on the paper were combined and weighed, in order that the food intake for the preceding 24 hours could be estimated. The food for the current day was then weighed out, and the weights of the animals taken.

The composition of individual diets is shown in Table 14 of the Appendix. Casein was used as a source of protein. In some of the rations this was prepared (casein 80) by leaching with 0.1% acetic acid for a week. It was then dried on the water bath and ground. In other rations it (casein 180) was purified by the method of Palmer and Kennedy[20]. Vitamins A and D were supplied by cod liver oil, and lard made up the total fat content to 15%. Corn starch, cellulose, and a salt mixture[21] were the other materials used. These constituents were mixed by hand, in amounts just sufficient to last one week, so as to prevent the destruction of vitamin A by oxidation. The rations fed at any one time in a series contained the same amount of vitamin B, supplied in the form of dried yeast.* This was purchased in lots of 10 to 20 pounds, and thoroughly mixed as further assurance of uniformity. Since it was desired to obtain accurate records of food intake, it was deemed best to measure the daily intake of every animal used in the experiment.

The rats for any one series were from the same litter, and were of the same sex. Males were preferred, because of the greater range in body weight, but there were 3 series of females fed by the regulated method. Four rats made up a series. Two of these received a low; and two a high protein diet. During the first week or two they were placed on a vitamin B-free ration in order to insure depletion of any stored vitamin B. One low protein, and one high protein animal received an additional vitamin B carrier in the

*The Harris Laboratories, Tuckahoe, New York.

form of the Osborne-Wakeman fraction[22]. This was fed separately on glass castors, and invariably was consumed immediately.

It should be stated at this place that the plural nature of vitamin B is fully realized. In this work the term vitamin B means those water-soluble factors which with vitamins A and D are necessary for the continued growth of the rat. One reason for the use of yeast in the present work is that it offers a source of all these water soluble components.

As stated previously, our first object was to determine whether or not the amount of protein in the ration bears any relation to the amount of vitamin B required to support growth. If the protein itself should contain any significant amount of the vitamin, it is obvious that the results might be misleading. In order to test that point specifically a comparison was made of the survival periods of rats on yeast-free rations, which varied widely in protein content. The results are summarized in Table 1. Rations 921 and 1056 were low in protein, Rations 897 and 1055 contained larger amounts than are commonly used.

TABLE 1.—SURVIVAL PERIOD OF RATS ON YEAST-FREE RATIONS

Rat No.	Ration No.	Weight		Survival Period days
		Initial gms.	Final gms.	
Males				
2386	921[1]	58	33	35
2388	921	71	41	35
2389	897[2]	66	40	27
2390	897	68	42	28
Females				
2591	921	51	35	33
2592	921	52	46	45
2589	897	50	40	33
2590	897	48	33	27
Females				
3358	1056[2]	33	25	37
3360	1056	36	23	41
3361	1055[2]	33	24	29
3362	1055	32	22	30
Males				
3907	1056	36	24	45
3920	1056	45	29	55
3917	1055	37	24	41
3921	1055	45	30	45

[1]Casein 180
[2]Casein 80

In order to obtain the greatest possible extreme in the vitamin content of the protein, the casein in one low protein ration, No. 921, was purified by the method of Palmer and Kennedy[20], after leaching with acidified water, and the casein of the high protein diet was extracted with acid water only. The latter ration would be expected to sustain life for a longer period of time if there were any difference in the vitamin B content of the two casein preparations. Since it did not do so we assume that neither preparation contained any significant amount of the vitamin. The same result was obtained in the other series, when casein 80 was used in both the high and low protein diets.

As a matter of fact the average survival periods of the rats receiving a generous allowance of protein were shorter than when the ration was slightly deficient in protein. This is in harmony with the conclusions of Drummond and coworkers[4], but because of the variability and small number of animals, the significance of our observations is uncertain.

In order to determine the activity of the Osborne-Wakeman fraction, a few rats received it as the sole source of vitamin B. The rate of gain is shown graphically in Fig. 1. Between 300 and 500 milligrams are required per day to sustain satisfactory growth to adult size when no yeast is supplied.

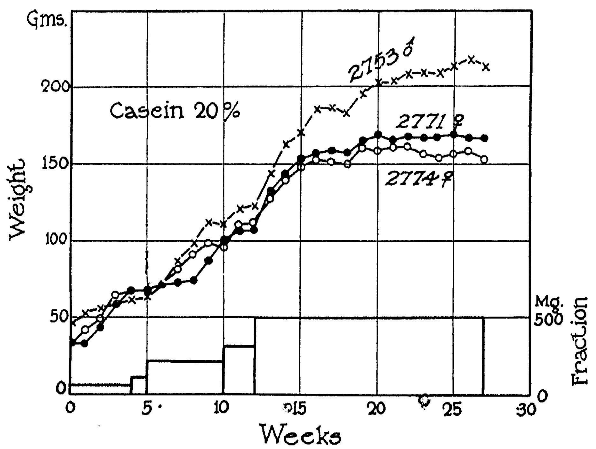

Fig. 1.—After a weight of 100 grams was reached a yeast-free ration required a supplement of at least 300 mg. daily of the vitamin concentrate in order to sustain normal growth.

Another question of some interest, especially when the regulated method of feeding was used, was the fuel value of the Osborne-Wakeman concentrate. This was disregarded in calculating the food intake, as its calorific value is unknown. We did, however, make the conventional feed analysis, by the methods of the Association of Official Agricultural Chemists[23], and computed its calorific value by use of the conventional factors. These values were then applied to some of the rats which were fed by the *ad libitum* procedure, and which received the Osborne-Wakeman fraction as a supplement. The data appear in Table 2. According to this calculation the calorific value of the fraction would be between 2 and 3% of the total intake. This could be ignored if the response to the supplement were sufficiently marked, but if only small differences are observed it would be necessary to take it into account.

TABLE 2.—PROPORTION OF TOTAL CALORIES SUPPLIED BY 250 MG. DAILY OF THE VITAMIN SUPPLEMENT

Rat No.	Total Osborne-Wakeman Fraction gms.	Total Intake		Osborne-Wakeman Fraction	
		gms.	calories	calories	Percentage of total calories
3722	49.00	1894	7955	201	2.53
256	54.25	1841	7732	222	2.87
276	50.75	1550	6510	203	3.19
228	47.25	1718	7216	194	2.69
232	45.50	1523	6397	187	2.92
3608	59.50	2538	10660	244	2.29

Before leaving this topic one possible source of error should be mentioned, though it is not believed to have materially affected the results observed. It should be emphasized that use of the Steenbock technique does not remove the possibility of coprophagy on the part of the rat. Frequently animals on the best of the rations we used, and growing rapidly, have been observed seizing fecal matter during the act of defacation before it could fall through the screen. The screen-bottomed cage does not eliminate coprophagy entirely, but serves to reduce it to a minimum.

Ad Libitum Feeding.—Passing on at this point to our procedure proper, one rat in each series received a ration low in protein and in vitamin. A second rat received this ration and in addition the vitamin supplement. The third received a high protein diet, but low in vitamin B. The fourth animal received both the high protein diet, and the concentrate. If protein and vitamin can supplement each other to any extent, it would be expected that the second and third animals would grow more rapidly than the first. The fourth should grow most rapidly of all.

A number of difficulties were encountered during the investigation, most of which were due to the fact that 3 rats of each series were given a ration that was in some degree inadequate. In some series the percentages of casein in both the low and high protein rations were kept constant, and the yeast content of the rations was increased as soon as one of the low protein rats ceased to grow. In the other series, either yeast, or casein, or both were increased, as seemed advisable. The dietary deficiencies rendered the animals more susceptible to disease and some series were discarded entirely for that reason. Furthermore, the behavior of the animals on the basal diet was not at all uniform. The ration might seem well adjusted in one series, but would fail to sustain satisfactory growth in the next. This made it impossible to use the same rations in different series during the same periods so it will be understood that the average weights, and food intakes, are not taken from periods when the rations consumed were the same. Records of individual weights, and food intakes, are given in the Appendix. Averages of these records are included in Table 3, and in Figs. 2, 3, and 4. The symbols used to designate the various groups are as follows:

GROUP.	DESCRIPTION OF RATION
LPLV	Ration is low in protein and in vitamin B.
LPHV	Ration is low in protein, but was supplemented with the vitamin B concentrate.
HPLV	Ration is high in protein, and low in vitamin B.
HPHV	Ration is high in protein, and was supplemented with the vitamin B concentrate.

TABLE 3.—WEIGHT AND FOOD INTAKE—FED *ad libitum*

Weeks	Weight, by weeks				Food Intake, by weeks			
	LPLV	LPHV	HPLV	HPHV	LPLV	LPHV	HPLV	HPHV
0	38.6	36.7	37.9	36.4				
1	38.9	35.9	37.8	34.9	28.3	25.7	20.3	19.2
2	44.4	44.8	45.8	51.9	32.6	32.0	27.7	33.4
3	47.3	52.9	53.5	69.3	31.7	36.2	32.4	45.6
4	52.4	60.0	59.9	86.9	34.5	41.3	35.7	54.2
5	56.6	67.1	67.8	107.3	34.3	42.6	35.7	57.8
6	64.2	78.7	76.7	130.1	36.9	46.0	38.7	65.5
7	69.7	90.2	87.4	147.1	40.0	51.9	41.7	71.3
8	76.5	101.7	96.4	160.3	41.6	54.3	43.8	69.8
9	84.8	111.1	105.4	172.3	47.8	57.7	47.3	70.5
10	89.7	119.1	116.0	184.9	44.5	57.7	47.2	70.0
11	93.8	125.5	125.1	195.1	41.9	53.4	48.3	71.3
12	101.7	134.8	136.7	204.9	47.3	59.1	54.0	73.4
13	106.4	140.3	145.2	210.1	47.0	58.5	54.5	71.2
14	113.0	146.3	151.4	215.7	50.5	57.6	55.3	67.6
15	120.7	150.7	159.8	217.7	53.3	59.0	59.6	68.4
16	128.4	156.6	168.2	223.2	57.4	59.5	60.3	68.6
17	138.1	162.7	175.2	224.5	57.6	60.2	58.7	64.2
18	143.0	166.7	180.5	224.3	58.4	61.6	60.6	65.7
19	149.0	168.3	186.4	226.3	59.2	59.9	63.5	66.3
20	155.2	174.3	193.5	227.5	55.7	57.9	62.0	64.0
21	158.4	177.2	196.8	229.9	60.5	63.8	64.1	66.2
22	162.7	180.5	201.6	230.9	53.8	54.8	56.9	57.8
23	167.9	178.6	208.1	234.8	60.1	61.4	65.8	64.2
24	163.5	176.7	204.3	227.9	56.6	57.5	60.8	60.4
25	165.8	177.9	208.9	226.8	59.4	59.9	66.6	64.1

As is to be expected the basal group, which received a ration low in both protein and vitamin B, grew slowly, as shown in Table 3 and in Fig. 2. If the amount of the vitamin supplement was increased, or if the percentage of protein in the ration was increased, in either case the rate of growth was accelerated. It is also shown that during the first half of the experimental periods these two groups grew at approximately the same rate. Following this time, however, the rate of gain of the group that received the vitamin supplement decreased more or less regularly, and at the end of the period the group receiving additional protein was considerably heavier. As would be predicted, the 4th group, which received a liberal supply of both vitamin B and protein, made much more rapid initial gains than any of the others. It will also be

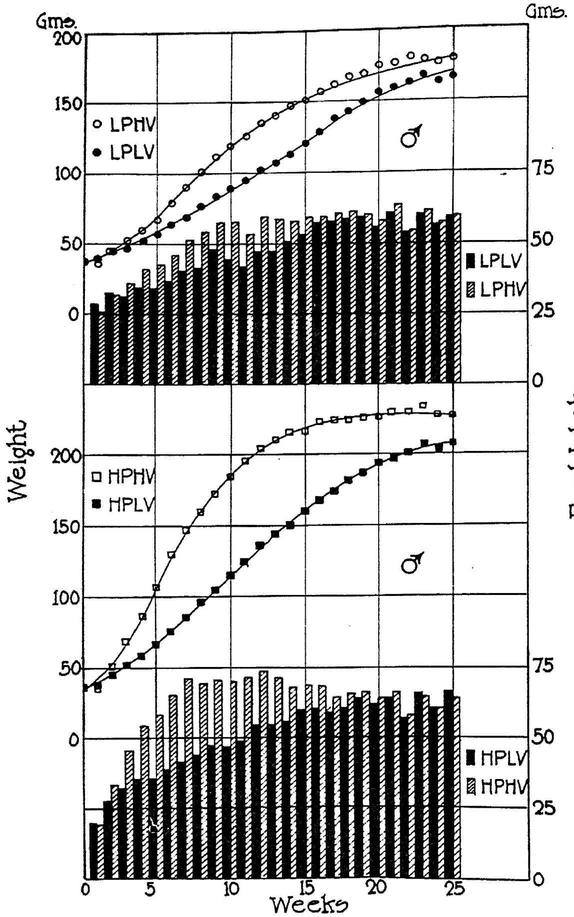

Fig. 2.—If additional vitamin B was provided, or if the percentage of protein in the basal ration was increased, the rate of growth was accelerated. If these two changes were made simultaneously the animals grew still more rapidly.

noted that the final weights of both groups on the high protein ration, are on a higher level than those on the low protein diet. The final weights of the two latter groups are apparently reduced by a low protein intake, regardless of the amount of vitamin B supplied.

There is naturally great variability in the growth rate of animals on deficient diets, so the significance of the additional gains attributed to single additions to the basal diet of either vitamin B or protein, might be regarded as doubtful. The rats were being depleted of vitamin B during the first week, so the gains made then

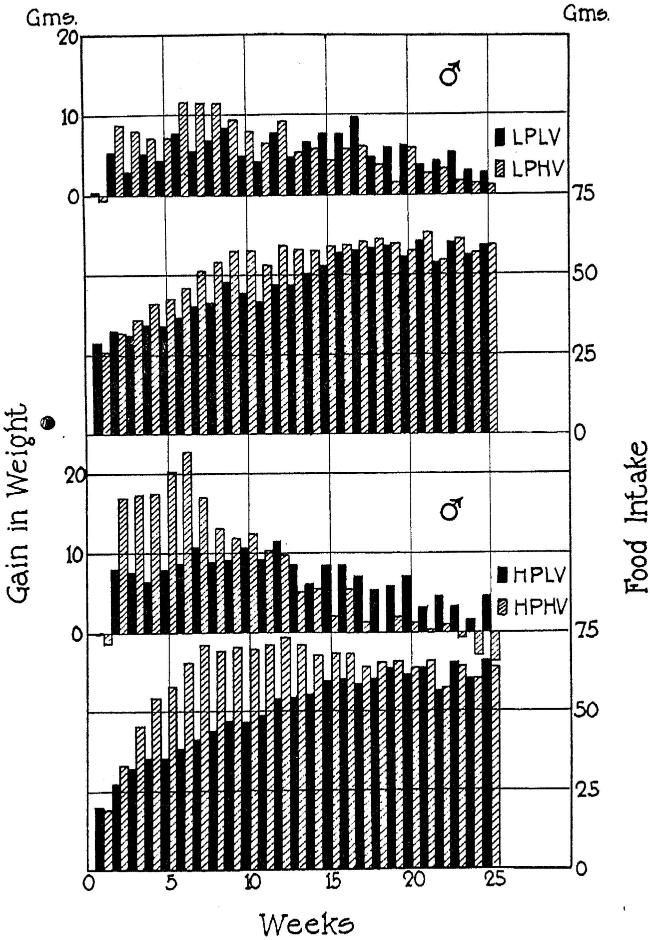

Fig. 3.—The average weekly gains have been plotted in order to show that growth is accelerated consistently in the early stages, by adding either vitamin B or protein to the basal diet.

are not significant. If, following that period, the gains of the two groups which received these additions are compared with those of the basal group, it is seen that they are larger without exception for 12 successive weeks. The calculated frequency of this event, if determined by chance alone, would be once in 4096 trials. It

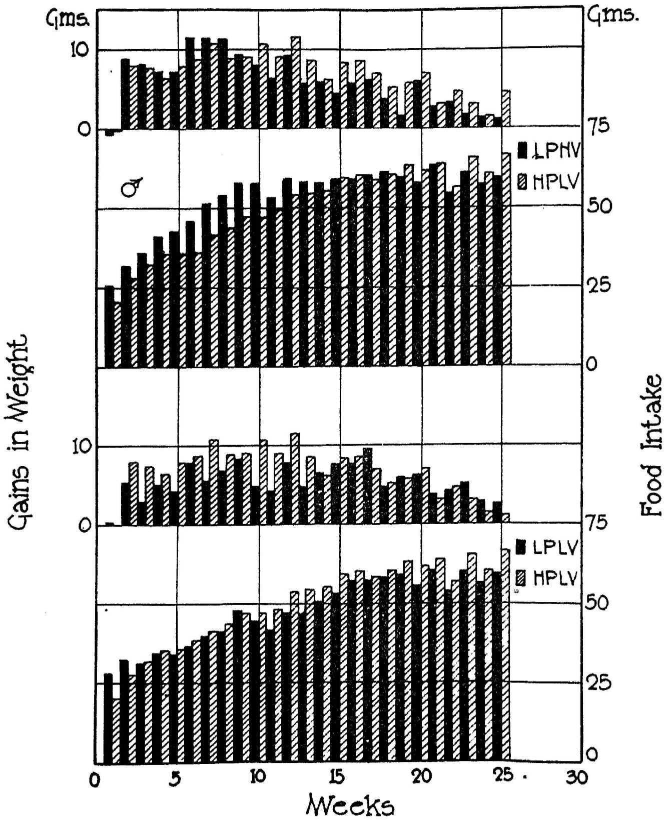

Fig. 4.—The groups receiving rations modified in one respect only are shown in the upper half. For the first 15 weeks these two groups grew at approximately the same rate, but the one on the high protein diet consumed considerably less food.

In the lower half of the figure the two groups which received rations low in vitamin B are compared. The food intake did not vary widely, but the animals on the high protein diet grew much more rapidly.

TABLE 4.—INCREASING THE SUPPLY OF EITHER VITAMIN B OR PROTEIN ACCELERATES THE GROWTH RATE

Weeks	LPHV Minus LPLV		HPLV Minus LPLV	
	Difference of means gms.	P. E. of difference	Difference of means gms.	P. E. of difference
1	−1.2	1.1	−0.5	0.9
2	3.5	1.5	2.6	1.1
3	5.1	1.8	4.7	1.3
4	2.1	1.0	1.4	1.0
5	2.9	1.3	3.7	1.4
6	3.7	1.8	1.0	1.9
7	6.1	1.4	5.3	1.1
8	4.7	1.4	2.1	1.3
9	1.2	1.7	0.8	1.9
10	3.1	1.3	5.8	1.5
11	2.3	1.1	4.9	1.4
12	1.5	1.6	3.8	1.5
13	0.8	1.1	3.8	1.7
14	−0.7	0.8	−0.4	1.1

seemed useless to pursue the examination further, but the probable errors* of the differences up to the 14th week have been calculated, and these appear in Table 4. In no case is the ratio of the difference to its probable error large, and in some cases it is less than one. When all are considered together, however, there is little doubt that these ratios are significant.

Not only the actual gains, but also the economy of food utilization seems significant, so the grams of food per unit gain have been calculated, and appear in Table 5. This with additional details is shown graphically in Fig. 5.

TABLE 5.—RELATION OF GAIN IN WEIGHT TO FOOD CONSUMED (GRAMS)

Weeks	Food consumed per gram gain per week				Food consumed per gram gain cumulative			
	LPLV	LPHV	HPLV	HPHV	LPLV	LPHV	HPLV	HPHV
1					80.7			
2	6.0	3.6	3.5	2.0	10.6	7.1	6.1	3.4
3	10.8	4.5	4.2	2.6	10.6	5.8	5.2	3.0
4	6.8	5.8	6.4	3.1	9.2	5.8	5.3	3.0
5	8.1	6.0	5.4	2.8	9.0	5.8	5.1	3.0
6	4.7	4.0	4.4	2.9	7.7	5.3	4.9	2.9
7	7.3	4.5	3.9	4.2	7.6	5.2	4.7	3.1
8	6.1	4.7	4.9	5.3	7.4	5.1	4.7	3.4
9	5.8	6.1	5.2	5.9	7.1	5.2	4.8	3.6
10	9.0	7.2	4.4	5.6	7.3	5.4	4.7	3.8
11	10.2	8.3	5.3	7.0	7.5	5.6	4.8	4.0
12	6.0	6.4	4.7	7.5	7.3	5.7	4.8	4.2
13	9.9	10.6	6.3	13.9	7.5	5.9	4.9	4.5
14	7.7	9.7	8.9	11.9	7.5	6.2	5.1	4.7
15	6.9	13.2	7.1	34.2	7.4	6.4	5.3	5.0
16	7.4	10.1	7.0	12.5	7.4	6.6	5.4	5.2
17	5.9	9.8	8.4	48.2	7.3	6.8	5.5	5.5
18	12.0	15.7	11.3		7.5	7.0	5.8	5.9
19	9.9	37.4	10.8	34.2	7.6	7.4	6.0	6.2
20	8.9	9.7	8.8	53.3	7.7	7.5	6.1	6.5
21	15.9	22.9	20.5	472.8	8.0	7.8	6.4	6.8
22	12.5	16.6	12.0	57.8	8.1	8.0	6.5	7.1
23	11.4	33.5	21.0	−698.1	8.3	8.3	6.8	7.5
24	18.9	39.6	38.5	−20.1	8.5	8.6	7.1	7.9
25	21.1	50.8	14.5	−16.9	8.8	9.0	7.3	8.4

It may be well to mention that near the close of the experimental periods the gains as calculated do not always equal the differences between the weights reported for the beginning and end of a week. This is due to the fact that some series dropped out. The gains are calculated from the averages of those animals that survived.

It will be observed during the early stages that as a rule the amount of food per unit gain varies inversely as the rate of gain. The 1st group, LPLV, grows most slowly of all and requires most food per unit gain. At this time the 3rd group, HPLV, is growing at practically the same rate as the 2nd, but its gains are more economical. The fourth group, HPHV, is growing much more rapidly than the others, and also much less food is required per unit gain. It will also be observed that after these animals have passed the point of

*We are indebted to Mr. B. H. Frame for helpful suggestions concerning the statistical treatment.

most rapid growth, in the 7th week, the gains become more costly. These animals continue up to the 12th week to grow more rapidly than those that do not receive the additional vitamin B supplement, HPLV, but they require more food per unit gain.

Possibly the most striking feature of Figure 5 is the fact that Groups 1 and 3, LPLV and HPLV, which did not receive the vitamin supplements, consumed almost precisely the same amount of food for 10 weeks. In spite of that fact, however, the ration of higher protein content sustained a consistently higher growth rate, at a consistently lower cost.

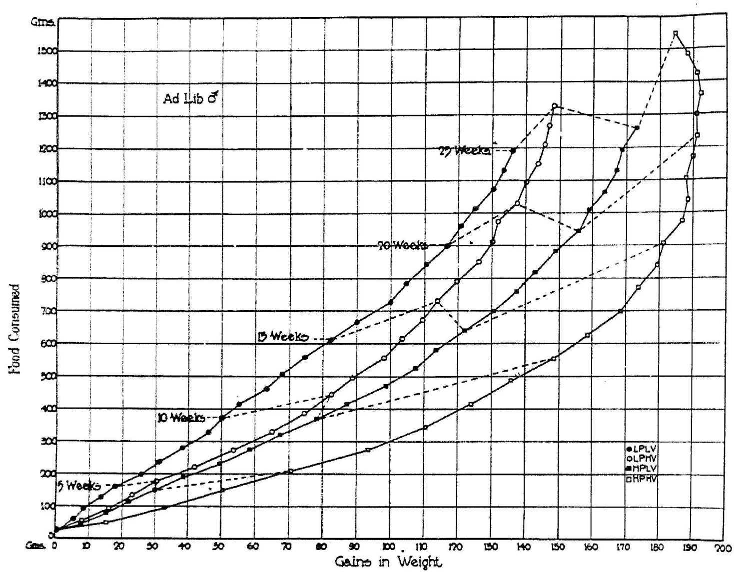

Fig. 5.—This shows that a liberal intake of food is usually associated with economical gains. The two groups which received inadequate amounts of vitamin B are exceptions. They consumed practically the same amount of food, but the group, HPLV, on the high protein diet grew more rapidly than the other.

This difference seemed important enough to warrant reexamination of the possibility that the casein may have contained enough of some part of the vitamin B complex to explain the acceleration of growth when the protein component was increased. This would not be impossible if the factor present in casein was identical with the first limiting factor in yeast. Palmer and Kennedy[24] offer evidence that casein which has been purified only by washing with water contains some unidentified factor of vitamin-like nature which is essential for growth in the rat. This objection has been met by experiments conducted with the purified casein, prepared by their method. Four of the series confined to rations containing this purified casein are shown graphically in Fig. 6.

It should be mentioned first that the observations of Palmer and Kennedy were amply confirmed. Rats receiving casein purified as they described require much more yeast than our purpose would permit us to use. In order to avoid the use of excessive

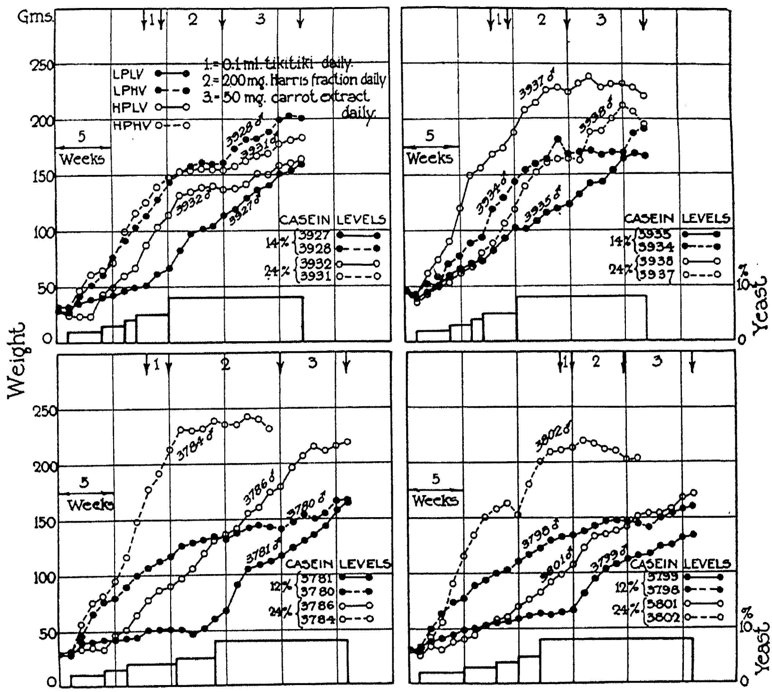

Fig. 6.—If the casein is rigidly purified, large quantities of yeast are required to support growth. The interpretation of these data is the same as that given for Fig. 1.

amounts various expedients were employed, such as giving all the rats in a series equal amounts of some supplement. Tikitiki[25], Harris yeast fraction*, and an alcoholic extract of carrots were all tried. The last named preparation proved most suitable.

It is seen that the results are in every respect identical with those previously described for the ordinary casein. The basal diet was improved by adding the vitamin B supplement, for the animal receiving the supplement increased its weight at a greater rate than did the animal on the basal ration. The approach to a limit-

*The Harris Laboratories, Tuckahoe, New York.

ing weight, which was practically the same for both rats on the low protein dietaries, was again noted, indicating that the improvement by the addition of vitamin B alone is limited in nature. The addition of protein again brought about the most lasting improvement. The rats receiving the high protein ration grew at a steady rate and finally passed in weight both the low protein animals. Thus with the unknown factor largely eliminated, it has again been shown that the addition of either vitamin B or protein to the basal ration causes a definite improvement in the rate of growth.

Our original purpose was to determine whether there is any interrelation between the amounts of protein and vitamin B in the ration. On the one hand, does a liberal amount of vitamin B diminish the amount of protein required, on the other, does a liberal supply of protein diminish the amount of vitamin B required. If one considers merely the rate of gain on the various rations, both questions might be answered in the affirmative. The addition of either to the basal diet had permitted more rapid growth without a simultaneous increase of the other. A consideration of the food intakes, however, makes this answer doubtful, for when the amount of vitamin B was increased, there was also an increase in the amount of food consumed. In this case, the increased food intake is a much more probable explanation of the increased growth rate, rather than that less protein was required. When the protein content of the ration was increased, the animals grew more rapidly even though their allowance of the vitamin was not increased, and the food intake was practically the same as that of the basal group. A possible explanation is, the greater growth rate was due to a lessened requirement for vitamin B, but other explanations are not excluded.

The final conclusion then is, the addition of protein alone to the basal diet markedly improved the utilization of food. The addition of vitamin B alone gave an ambiguous result. No definite evidence was obtained that there is any interrelation between the physiological functions of protein and vitamin B.

It should be borne in mind, however, that the percentage of casein, even in the high protein diets, was not excessively high, and it is entirely possible that different results would have been obtained, had we used rations containing as much protein as those of Reader and Drummond[5 6].

Regulated Method of Feeding.—Another study was conducted simultaneously with the one just described, using practically the same procedure, but with one important exception. All four animals in any one series received, so far as is practicable, the same amount of food. The daily allowance of all four animals was regulated almost entirely by the rat that had consumed the least dur-

TABLE 6.—WEIGHT AND FOOD INTAKE OF MALES—FED BY REGULATED METHOD (GRAMS)

Weeks	Weight, by weeks				Food Intake, by weeks			
	LPLV	LPHV	HPLV	HPHV	LPLV	LPHV	HPLV	HPHV
0	37.5	37.3	37.3	36.8				
1	44.0	43.0	48.5	50.3	31.5	31.1	31.5	31.8
2	55.0	53.5	67.5	69.8	37.4	36.7	37.6	37.4
3	63.5	64.5	81.8	84.5	40.6	42.0	40.9	40.9
4	68.3	70.3	91.3	94.8	41.4	41.2	41.7	41.0
5	73.3	76.0	102.5	108.0	39.6	40.4	40.5	40.4
6	79.5	83.5	112.3	120.0	44.5	44.3	43.4	43.8
7	81.5	86.0	118.5	124.0	39.2	38.1	38.2	38.8
8	88.8	93.0	126.3	131.3	44.7	45.2	43.8	43.9
9	95.5	99.0	133.8	139.8	45.8	45.6	47.1	46.6
10	97.0	103.5	135.3	144.5	45.2	44.9	47.6	45.7
11	101.0	106.8	140.8	147.0	47.0	46.3	47.3	46.2
12	103.8	110.5	148.0	154.0	50.1	50.0	50.0	50.0
13	112.0	119.3	162.3	166.3	54.1	54.4	56.0	55.1
14	117.0	124.5	166.8	175.3	53.0	53.5	52.6	52.8
15	121.0	127.8	162.3	172.3	49.4	47.1	44.1	47.3
16	121.5	129.8	166.8	175.0	43.6	45.9	50.0	45.8
17	123.8	132.3	165.8	177.5	46.7	46.5	44.1	46.2
18	125.8	136.3	167.0	178.3	48.1	45.4	47.5	47.0
19	133.0	143.5	173.0	184.8	48.6	49.9	49.0	49.6
20	133.8	146.0	173.3	186.8	49.6	49.2	49.1	48.9
21	137.5	151.3	180.8	192.3	51.2	51.2	50.8	50.8
22	141.5	155.0	188.0	194.5	54.0	54.2	54.3	54.5
23	141.5	154.5	185.5	191.5	49.6	48.3	48.3	48.8
24	146.0	160.0	190.0	195.8	49.1	49.1	48.6	48.8
25	149.0	166.0	197.0	202.8	53.9	55.2	55.0	55.1
26	153.8	170.0	202.0	209.3	54.7	52.2	54.9	52.8
27	159.3	182.3	206.0	218.7	54.3	54.6	54.7	54.9
28	174.0	206.0	223.0	234.0	48.5	51.7	48.6	48.3
29	177.0	205.0	229.0	235.0	51.0	48.3	51.7	51.7
30	180.0	211.0	230.0	232.0	54.7	58.0	55.0	54.4
31	188.0	211.5	235.0	238.0	54.6	51.9	54.6	54.9
32	188.5	213.0	232.0	238.0	58.3	58.9	58.7	57.7
33	195.0	214.0	235.0	237.0	64.8	64.4	64.3	64.6
34	199.0	220.0	246.0	250.0	68.3	69.3	71.6	69.9

TABLE 7.—WEIGHT AND FOOD INTAKE OF FEMALES—FED BY REGULATED METHOD (GRAMS)

Weeks	Weight, by weeks				Food Intake, by weeks			
	LPLV	LPHV	HPLV	HPHV	LPLV	LPHV	HPLV	HPHV
0	39.7	41.0	39.7	37.7				
1	44.3	45.7	54.0	50.7	33.1	32.6	33.1	32.0
2	56.0	56.0	74.0	70.0	42.2	42.3	42.4	43.3
3	65.3	66.7	88.0	85.0	46.6	47.1	46.6	46.5
4	74.3	76.3	102.0	102.0	50.1	50.0	49.9	50.2
5	82.3	83.3	110.3	110.7	47.4	47.8	46.9	47.2
6	82.3	83.7	111.3	114.0	39.6	39.3	38.7	40.0
7	84.0	87.3	115.7	117.7	39.4	39.4	38.3	39.9
8	85.0	87.3	116.0	121.0	38.4	38.2	39.1	37.5
9	88.0	94.0	123.0	127.3	39.3	41.1	39.7	41.0
10	86.7	95.7	125.3	131.7	41.0	44.9	44.4	45.0
11	87.7	94.0	127.7	129.7	45.8	44.1	44.4	44.3
12	91.0	96.7	128.3	132.7	44.0	41.9	42.3	42.4
13	95.7	103.0	134.7	137.7	44.2	46.6	45.3	44.9
14	97.3	106.3	132.3	137.3	45.1	44.4	44.9	46.3
15	102.7	113.3	136.7	140.0	45.2	46.8	46.9	45.0
16	101.0	112.7	136.7	139.3	43.4	45.7	45.9	41.6
17	103.7	117.7	135.3	140.0	51.9	50.3	48.2	49.4
18	108.7	122.0	139.3	146.0	51.8	51.3	53.3	51.8
19	119.3	132.0	147.3	156.0	57.4	59.7	58.7	58.8
20	122.7	134.0	146.3	155.3	56.2	55.0	51.1	54.8
21	124.0	130.3	148.3	156.7	53.4	54.1	56.3	53.4
22	124.3	134.3	152.0	161.3	51.8	51.2	53.0	51.8
23	127.3	137.3	151.0	160.7	50.0	49.5	49.7	50.5
24	129.0	143.0	154.0	163.0	49.3	50.8	50.1	50.0
25	127.0	142.3	154.0	160.7	48.4	48.8	48.3	47.2

ing the previous 24 hours. Needless to say, such a procedure involves considerable technical difficulty, partly due to the very considerable variation in the daily intake of any one animal. Another difficulty is, one rat may set the pace for a time, and then another will unexpectedly reduce its intake far below the amount expected.

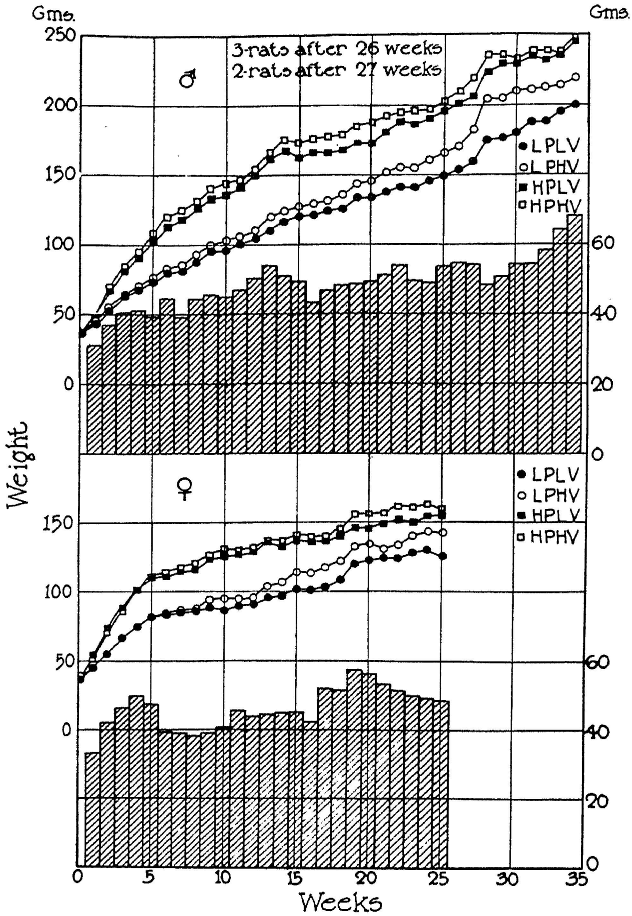

Fig. 7.—All animals of a series received the same amount of food. The addition of vitamin B alone accelerated the rate of growth slightly, but this may not be significant (see Table 8). The addition of protein alone induced a marked acceleration.

In order to equalize the food intakes within a reasonable time, this often makes it necessary to restrict severely the allowances of the others. Some series had to be discarded because one member would never consume sufficient food to sustain consistent growth. Others were discarded because of the development of respiratory disease.

Another difficulty, occurring less frequently in the *ad libitum* series, was in adjusting the percentages of protein and yeast in the rations low in both factors. It was desired to keep the level of each as low as possible, and still permit a slow but consistent rate of growth. It soon developed, however, that a ration may be quite satisfactory in one series, but in another will not be consumed in sufficient quantity to sustain growth at all. In spite of these difficulties, seven series in all were obtained that seemed

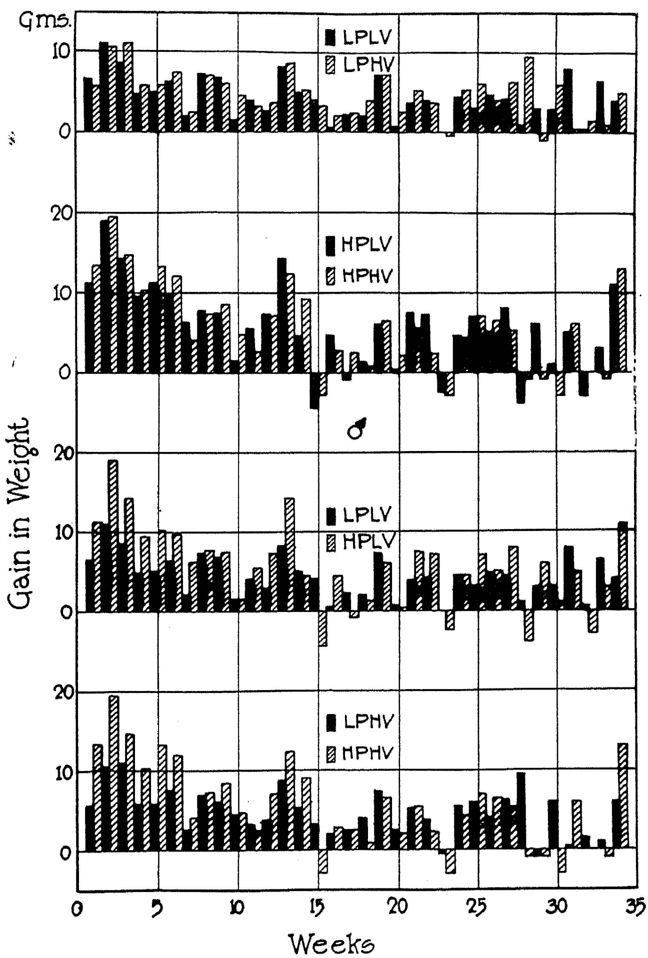

Fig. 8.—The upper half shows that when the animals received the same amount of food acceleration of the growth rate was not induced merely by increasing the allowance of vitamin B.

The lower half shows that a more liberal provision of protein was followed by a more rapid growth rate.

sufficiently satisfactory for our purpose. A summary of our data is shown in Tables 6 and 7, and in Figs. 7, 8, and 9.The individual weights, and food intakes, are given in Table 16 of the Appendix.

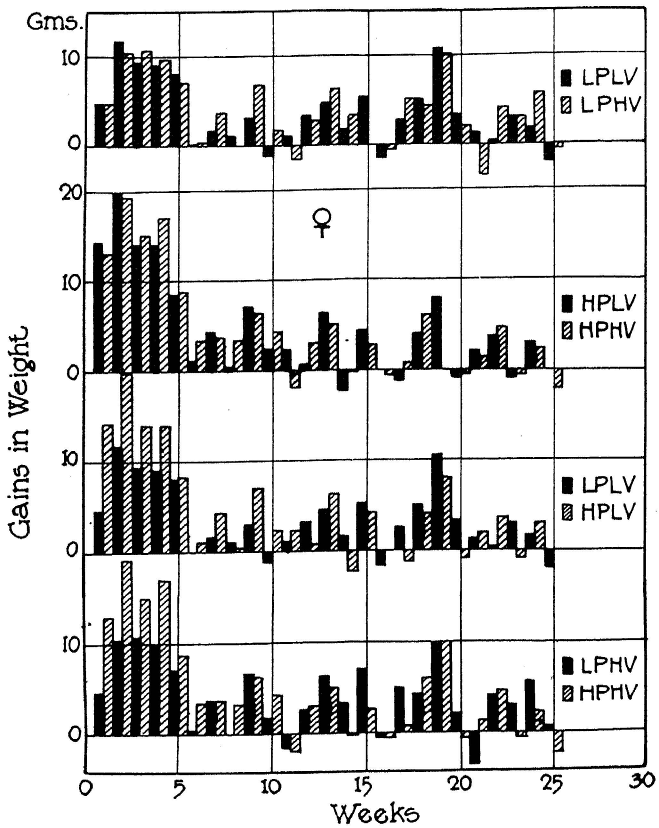

Fig. 9.—See Fig. 8 for comments.

As would be expected the group on the basal diet grew most slowly. It will also be observed that the animals which received an additional allowance of vitamin B, LPHV, gained somewhat more rapidly than the basal group. This increase in gain, however, was slight until after 15 weeks had elapsed. A difference that is closely parallel to this is found in the two groups on the high protein level. One of these, HPHV, also received an additional allowance of vitamin B, and grew more rapidly, but we are not convinced that the increased rate of growth in either case is significant.

In order to examine this possible significance more closely, we have added up the amount of supplement supplied, and compared it with the additional gains that might be ascribed to it. This calculation appears in Table 8. The gain in each case is the difference in weight of two groups on the same level of protein and shows how much additional growth was due to the vitamin supplements.

TABLE 8.—COMPARISON OF GAINS DUE TO ADDITIONAL VITAMIN B SUPPLEMENT AND THE AMOUNT OF SUPPLEMENT SUPPLIED

	Males			Females		
		Gain			Gain	
Weeks	Supplement gms.	LPHV gms.	HPHV gms.	Supplement gms.	LPHV gms.	HPHV gms.
1	1.4	−0.8	2.3	0.4	0.0	−1.3
2	2.8	−1.3	2.8	0.7	1.3	−2.0
3	4.2	1.3	3.3	1.1	2.7	−1.0
4	5.6	2.3	4.0	1.5	3.4	2.0
5	7.2	3.0	6.0	2.2	2.4	2.3
6	8.9	4.3	8.3	2.9	2.7	4.7
7	10.9	4.8	6.0	3.6	4.7	4.0
8	12.9	4.5	5.5	4.3	3.7	7.0
9	14.8	3.8	6.5	5.0	7.4	6.3
10	16.8	6.8	9.8	5.7	10.4	8.3
11	18.8	6.0	6.8	6.5	7.7	4.0
12	20.9	7.0	6.5	7.3	7.0	6.3
13	23.0	7.5	4.5	8.4	8.7	5.0
14	25.3	7.8	9.0	9.9	10.3	7.0
15	27.7	7.0	10.5	11.4	12.0	5.4
16	30.0	8.5	8.8	13.0	13.0	4.7
17	32.3	8.8	12.3	14.7	15.3	6.7
18	34.7	10.8	11.8	16.3	14.7	8.7
19	37.0	10.8	12.3	17.9	14.0	10.7
20	39.3	12.5	14.0	19.6	12.7	11.0
21	41.7	14.0	12.0	21.2	7.7	10.3
22	44.0	13.8	7.0	22.8	11.3	11.3
23	46.3	13.3	6.5	24.5	11.3	11.7
24	48.7	14.3	6.3	26.1	15.3	11.0
25	51.0	17.3	6.3	27.7	16.7	8.7

It is obvious that if the supplement itself has any considerable nutritional value, the amount supplied the males could easily account for all of the additional gain. The interpretation of differences between the females is not quite so obvious, for the additional increase in weight is often more than the weight of the supplement consumed. Part of the difficulty is due to uncertainty as to the nature of the gains. If these consisted largely of fat, they could not be explained by the calorific value of the supplement. If, however, the gain consisted largely of protein, the nutritional value of the supplement might be a sufficient explanation, for every gram of protein is accompanied by approximately 3 grams of water.

An effort was made to obtain some measure of the nutritional value of the fraction by incorporating a large quantity in a ration and feeding it directly.* As finally formulated this ration consisted of casein 12, Osborne-Wakeman Fraction 80, cod liver oil 2, salts 4, agar 2. Five rats were given this diet but all suffered from violent diarrhea, thus making it impossible to tell much about the nutri-

*These feeding trials were carried out by Dr. L. R. Richardson.

tional properties of the fraction. The most important observations on this point are shown in Table 9.

TABLE 9.—NUTRITIONAL PROPERTIES OF THE OSBORNE-WAKEMAN FRACTION

Rat No.	Weight		Survival Period
	Initial gms.	Final gms.	days
8235f	31	23	10
8236m	29	28	11
8232m	32	29	5
8238m	32	30	5
8237f	34	33	5

It was not feasible to measure the amount of food consumed as it is exceedingly hygroscopic, and considerable quantities adhered to the animals themselves. It seems, however, that the fraction must have supplied a considerable quantity of metabolizable energy, for except in one case the losses in weight were slight, in spite of the severe intestinal disturbance. For the present, then, it is concluded that under the conditions we observed, rats which receive the same calorific intake will grow at aproximately the same rate regardless of the amount of vitamin B consumed.

If it is assumed for the time that the difference is not significant, then this is in sharp contrast to the observations when the rats were fed *ad libitum*. It is our view that our data do not sup-

TABLE 10.—RELATION OF GAIN IN WEIGHT TO FOOD CONSUMED, MALES

Weeks	Food consumed* per gram gain per week				Food consumed* per gram gain cumulative			
	LPLV	LPHV	HPLV	HPHV	LPLV	LPHV	HPLV	HPHV
1	4.8	5.4	2.8	2.4	4.8	5.4	2.8	2.4
2	3.4	3.5	2.0	1.9	3.9	4.2	2.3	2.1
3	4.8	3.8	2.9	2.8	4.2	4.0	2.5	2.3
4	8.7	7.2	4.4	4.0	4.9	4.6	2.8	2.6
5	7.9	7.0	3.6	3.1	5.3	4.9	3.0	2.7
6	7.1	5.9	4.5	3.7	5.6	5.1	3.1	2.8
7	19.6	15.2	6.1	9.7	6.2	5.6	3.4	3.1
8	6.2	6.5	5.7	6.1	6.2	5.7	3.6	3.4
9	6.8	7.6	6.3	5.5	6.3	5.9	3.8	3.5
10	30.1	10.0	31.8	9.6	6.9	6.2	4.2	3.8
11	11.8	14.3	8.6	18.5	7.2	6.6	4.4	4.1
12	18.2	13.3	6.9	7.1	7.7	6.9	4.6	4.3
13	6.6	6.2	3.9	4.5	7.5	6.8	4.5	4.3
14	10.6	10.2	11.7	5.9	7.7	7.0	4.8	4.4
15	12.4	14.5			7.9	7.3	5.3	4.9
16	87.1	22.9	11.1	16.6	8.4	7.6	5.5	5.1
17	20.8	18.6		18.5	8.7	7.9	5.9	5.4
18	24.1	11.3	38.0	62.7	9.1	8.1	6.2	5.7
19	6.7	6.9	8.2	7.6	8.9	8.0	6.3	5.7
20	66.1	19.7	196.2	24.5	9.4	8.3	6.6	6.0
21	13.7	9.7	6.8	9.2	9.5	8.3	6.6	6.1
22	13.5	14.5	7.5	24.2	9.7	8.5	6.7	6.4
23					10.1	9.0	7.1	6.8
24	10.9	8.9	10.8	11.5	10.2	9.0	7.2	6.9
25	18.0	9.2	7.9	7.9	10.4	9.0	7.3	7.0
26	11.5	13.1	11.0	8.1	10.4	9.1	7.4	7.0
27	12.6	8.6	6.8	10.3	10.5	9.1	7.3	7.1
28	48.5	5.4			10.8	8.8	7.7	7.4
29	17.0		8.6	51.7	11.0	9.2	7.7	7.8
30	18.9	9.7	55.0		11.1	9.3	8.1	8.2
31	6.8	103.8	10.9	9.2	10.9	9.6	8.2	8.2
32	116.7	39.3			11.3	9.8	8.5	8.6
33	10.0	64.4	21.4		11.2	10.2	8.9	9.0
34	17.1	11.6	6.5	5.4	11.4	10.2	8.7	8.7

*In grams.

TABLE 11.—RELATION OF GAIN IN WEIGHT TO FOOD CONSUMED, FEMALES

Weeks	Food consumed* per gram gain per week				Food consumed* per gram gain, cumulative			
	LPLV	LPHV	HPLV	HPHV	LPLV	LPHV	HPLV	HPHV
1	7.1	7.0	2.3	2.5	7.1	7.0	2.3	2.5
2	3.6	4.1	2.1	2.2	4.6	5.0	2.2	2.3
3	5.0	4.4	3.3	3.1	4.8	4.8	2.5	2.6
4	5.6	5.2	3.6	3.0	5.0	4.9	2.8	2.7
5	5.9	6.8	5.6	5.4	5.1	5.2	3.1	3.0
6		119.0	38.7	12.0	6.1	6.1	3.6	3.4
7	2.4	10.7	8.8	10.9	6.7	6.4	3.9	3.7
8	38.4		118.3	11.2	7.4	7.3	4.4	4.0
9	13.1	6.2	5.7	6.5	7.8	7.1	4.5	4.2
10		26.9	19.0	10.4	8.9	7.7	4.9	4.5
11	45.8		19.1		9.6	8.8	5.3	5.1
12	13.2	15.7	63.1	14.1	9.9	9.1	5.8	5.4
13	9.5	7.4	7.2	9.0	9.8	9.0	5.8	5.5
14	27.0	13.3			10.3	9.2	6.4	6.0
15	8.5	6.7	10.8	16.9	10.2	8.9	6.6	6.3
16					11.2	9.7	7.1	6.8
17	19.5	10.1		73.8	11.5	9.7	7.7	7.2
18	10.4	11.8	13.3	8.6	11.4	9.8	7.9	7.3
19	5.4	6.0	7.3	5.9	10.6	9.4	7.9	7.2
20	16.9	27.5			10.9	9.8	8.4	7.7
21	39.9		28.1	39.9	11.3	10.8	8.8	8.0
22	156.9	12.8	14.4	11.1	11.9	10.9	9.0	8.1
23	16.7	16.5			12.1	11.0	9.5	8.6
24	29.5	9.0	16.7	21.4	12.4	10.9	9.7	8.8
25					13.2	11.5	10.1	9.4

*In grams.

port the conclusion that, if animals consume the same amount of energy, those receiving a liberal allowance of vitamin B will grow more rapidly than those that receive a limited allowance.

It was noted in the *ad libitum* studies that if two groups of rats receive the same amount of energy, those receiving a liberal allowance of protein grow considerably more rapidly than those whose allowance is limited, and that observation was confirmed when the regulated method of feeding was followed. This was emphasized in Figs. 8 and 9, in which the weekly gains only are plotted. A more quantitative expression of this difference is found in Tables 10 and 11, and Figs. 10 and 11, in which the food consumed per unit gain has been calculated. The interpretation of the tables is probably obvious, but some explanation may be needed. The calculations on the left-hand side of the tables use the data of each individual week separately. On the right-hand side of the page the calculations use the total food intake, and the total gain, from the beginning up to the week indicated.

As would be expected from the discussion of Table 8, these data are not interpreted as showing a more economical utilization of food by the animals which received the more liberal supply of vitamin B. The data do show very clearly, however, that the animals which received an ample supply of protein required very much less food per unit gain than did those on the lower protein levels. In order to determine whether this difference might be due to different degrees of absorption from the intestinal tract, single digestion trials* were run, one on Ration 1009 low in protein, and one on Ration 1072 high in protein. The apparent digestibility of the dry matter of Ratio 1009 was 92.0%, and of Ration 1072 was 92.6%. Using another pair of rats, the energy values of the mixed excreta were determined. The rat on the low protein diet excreted 9.3% of the energy consumed, the one on the high protein diet ex-

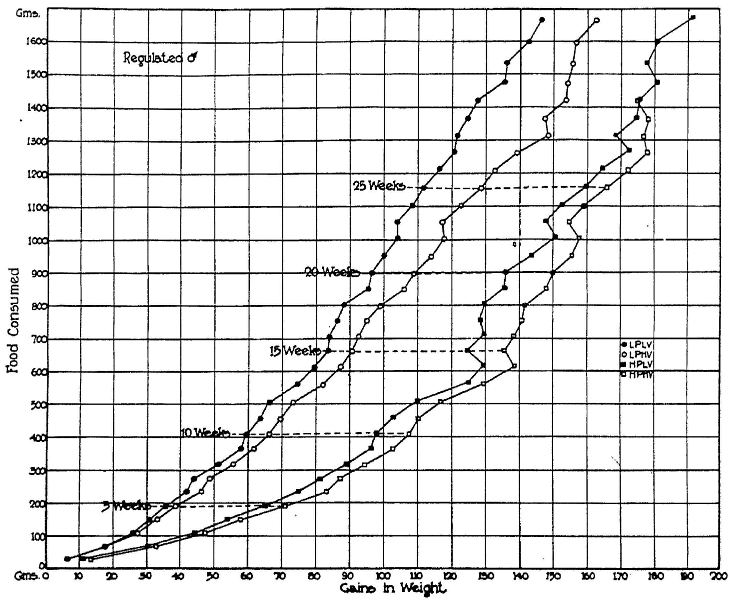

Fig. 10.—Although the animals received practically the same amount of food in the same time intervals, the gains were slightly larger when the allowance of vitamin B' was increased. There is some doubt as to the significance of this difference (see Table 6). When the percentage of protein was increased the rate of gain was markedly accelerated.

creted 8.8%. The differences in rate of gain were not due to differences in digestibility of the rations. In order to establish with more certainty the fact that the additional protein had accelerated the growth rate, we have calculated the differences between the mean weights of the groups on the low and on the high protein rations. The number of rats in any one group was too small for satisfactory statistical treatment, so all animals of the same sex which received the same amount of protein were combined regard-

*We are indebted to E. W. Cowan for the chemical analyses, and to U. S. Ashworth for the determinations of the heats of combustion of food and excreta.

less of the vitamin B intake. This gives 8 males and 6 females on each level of protein. Separate calculations were made for each sex. It will be observed that the males on the high protein ration made the greater gain for 14 successive weeks, and the females made this greater gain for 11 successive weeks. The calculated frequency of such events, if determined by chance alone, would be once in 16,384 trials for the males, and once in 2,048 trials for the

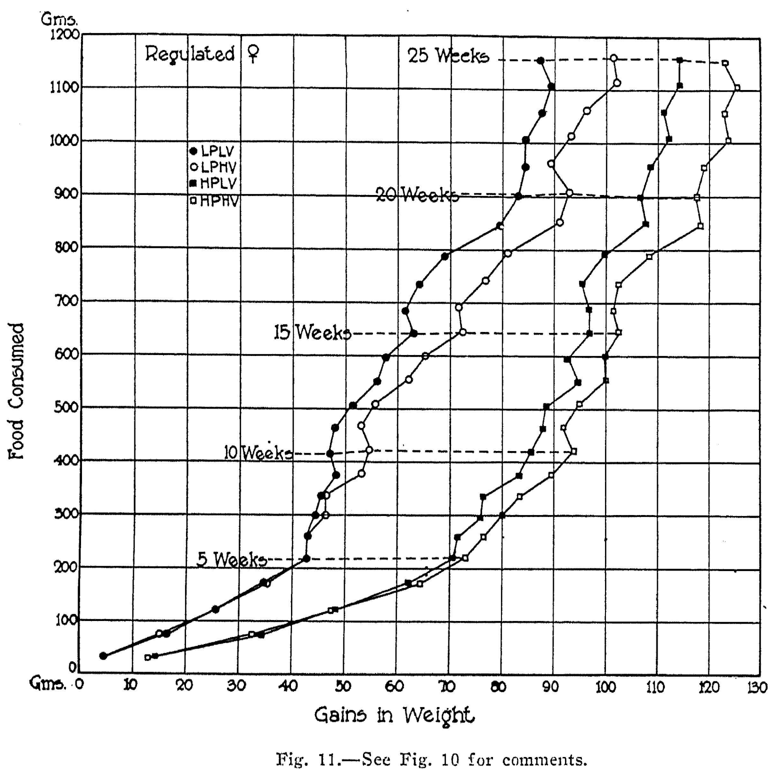

Fig. 11.—See Fig. 10 for comments.

females. As an additional precaution, however, we have calculated the probable errors of the differences in the rate of gain. For the first 7 weeks the ratios of the differences in gains of the males, to the probable errors, carry a reasonable degree of significance. Following that time they are of no significance. The ratios of the differences in gains of the females to the probable errors are without significance after the fourth week. These data are reproduced in Table 12.

TABLE 12.—INCREASING THE SUPPLY OF PROTEIN ACCELERATES THE GROWTH RATE

	HP Minus LP Males		HP Minus LP Females	
Weeks	Difference of means gms.	P. E. of difference	Difference of means gms.	P. E. of difference
1	6.3	1.1	9.0	1.2
2	8.5	1.3	8.7	1.2
3	4.8	1.2	4.5	1.4
4	4.6	1.9	6.2	2.2
5	6.9	2.4	1.0	1.2
6	4.0	2.1	2.1	1.6
7	2.9	1.0	1.3	1.3
8	0.4	0.9	1.3	3.6
9	1.6	1.4	1.8	3.2
10	0.1	2.7	3.2	2.9
11	0.4	2.4	0.5	1.8
12	3.9	2.7	−1.2	2.6
13	4.8	1.8	0.2	3.8
14	1.6	1.7	−3.8	1.7
15	−7.4	1.7	−2.7	2.6

If an increase in the supply of protein accelerated the rate of growth this might seem to disagree with the observation of Hartwell, and of Reader and Drummond that a considerable increase in the supply of protein retarded the rate of growth. However, the amounts of protein even in our high protein diets were not extreme, and we do not believe there is necessarily any discrepancy. Our observations are in harmony with those of Mitchell and collaborators[26]. They reported that on a low level of nitrogen intake, the growth rate of rats was accelerated by improving the biological value of the amino acid mixture, even though the calorific intake was the same.

It should be mentioned that the energy values of the rations, and their constituents, as given in Table 14 of the Appendix, were not calculated from their heats of combustion, because the gross energy of protein is considerably higher than its metabolizable energy. For that reason the intake of calories was calculated from the factors given by Rubner[27]. These are 4.1 calories per gram of protein or carbohydrate and 9.3 calories per gram of fat. The validity of our calculations obviously depends then largely on the applicability of these factors, especially for protein. Rubner's value of 4.1 calories per gram of protein was based on studies in which meat was largely used as a source of that constituent and man was the experimental subject. We actually used casein, which has a slightly higher heat of combustion, but we are unable to say whether or not the factor 4.1 calories per gram is too low. Such calculations as we are able to make with the data now available indicate that the animals on the high protein diets may possibly have received approximately 1.75% more energy than we supposed. We believe it is impossible for any such degree of variability to account for the difference in gains.

Another element of uncertainty deserves some mention and that is the variable degree of activity of the animals. It was shown by Hitchcock[28] that this may be markedly influenced by the amount of protein in the ration, which is the constituent we were most concerned with. So far as we are aware, however, an exact determination of the amounts of energy expended in activity by animals on different protein levels has never been made. Although we have not attempted to estimate these amounts their possible significance should not be forgotten, as was emphasized by Mitchell[10b]. The basal metabolism of our animals, reported elsewhere[29], was apparently the same, regardless of the amount of protein consumed.

DISCUSSION

It remains, then, to attempt the application of these observations to our original question. For emphasis it is stated in two forms. (1) Does the amount of vitamin B that is necessary for a certain rate of growth vary with the quantity of protein in the diet, and (2) conversely, does the amount of protein that is necessary for a certain rate of growth vary with the amount of vitamin B that is supplied. It is our view that these questions can be answered in the negative.

When the regulated method of feeding was used, it was observed that the high protein groups grew more rapidly than those on the low protein rations, and that in neither case did the addition of vitamin B supplements have any significant effect on the growth rate. This is interpreted as evidence that the amount of vitamin B supplied determines how much food can be consumed, but has no effect on the rate of growth that quantity of food will sustain. Furthermore, the effect of increasing the protein content of the diet is specific, and does not vary with the amount of vitamin B supplied.

When the *ad libitum* method of feeding was used one set of observations was in harmony with those just described in the preceding paragraph. It was again observed that the high protein groups grew more rapidly than those on the low protein rations, whether the amount of vitamin B supplied was high or low. This more rapid growth could be explained in at least two ways. First, it may be assumed that the animals grew faster when they received more protein because they required less vitamin B. A second explanation is, the vitamin B requirement is unchanged and the acceleration of growth was due solely to the more liberal allowance of protein. Another set of observations, however, failed to yield the same result as the regulated method, for when the *ad libitum* method was used the growth rate was accelerated by fortifying either the low or high protein ration with an additional allowance of vitamin B. The more rapid growth in this case also could be explained in either of two ways. First, it may be that when the amount of vitamin B is increased, less protein is required. Second, and with greater probability, when the amount of vitamin B is increased the food intake is increased also.

Our final conclusion is, the evidence does not support the contention that the amount of vitamin B necessary for a certain rate of growth varies with the quantity of protein in the diet. Stated conversely, the amount of protein necessary for a certain rate of growth does not vary with the amount of vitamin B that is supplied.

A closely related question was stated as part of our original purpose: If a ration is deficient in both protein and vitamin B, is it made more adequate for growth by increasing the amount singly of either constituent. It is our view that either increase does make the ration more adequate. So far as protein is concerned, our data would seem to leave no room for doubt. When tested by either method, the high protein diet supported more rapid growth than did the low protein diet.

As to the effect of augmenting the supply of vitamin B, it may be possible to take two opposing positions. The regulated method of feeding did not yield convincing evidence that an increase of this constituent made the low vitamin ration more adequate. The *ad-libitum* method, however, indicates that both the low and high protein rations were made more adequate by supplying more vitamin B, and it seems that experience would make it necessary to adopt this viewpoint, regardless of the outcome with any particular technique. It seems to us that the increased food intake, due to a liberal supply of vitamin B, is as significant as the difference in body weight.

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APPENDIX

TABLE 13.—COMPOSITION OF RATION CONSTITUENTS

Material	Water per cent	Ash per cent	Protein per cent	Ether Soluble per cent	Carbo-hydrate per cent	Crude Fiber per cent	Calories per gram
Starch	11.08	0.02	-----	-----	88.90	-----	3.645
Cellulose	4.96	0.47	-----	-----	-----	-----	-----
Casein 80	5.63	2.58	88.17	1.02	-----	-----	3.710
Casein 180	7.44	1.90	88.30	0.82	-----	-----	3.696
Dried Yeast	6.36	11.73	50.25	1.39	29.25	1.02	3.389
Osborne-Wakeman Fraction	5.65	2.11	55.94	0.19	36.11	-----	3.782
Cod Liver Oil	0.40	-----	-----	-----	-----	-----	9.300
Lard	0.50	-----	-----	-----	-----	-----	9.300

TABLE 14.—COMPOSITION OF RATIONS
(Only the variable components are listed here)

Ration No.	Casein %	Yeast %	Protein %	Starch %	Calories %
897	35.0	0.0	30.86	55.5	3.55
921	10.5	0.0	9.26	80.0	3.54
957	7.0	7.0	9.69	76.5	3.52
958	31.0	7.0	30.85	52.5	3.53
959	7.5	6.0	9.63	64.5	4.23
960	31.5	6.0	30.79	40.0	4.24
961	7.0	7.0	9.69	64.0	4.22
962	31.0	7.0	30.85	40.0	4.24
968	3.0	9.0	7.17	66.0	4.22
969	30.0	9.0	31.00	39.0	4.23
1009	6.0	8.0	9.31	64.0	4.22
1010	32.0	8.0	32.23	38.0	4.24
1019	6.0	9.0	9.81	63.0	4.22
1020	32.0	9.0	32.74	37.0	4.24
1035	9.0	7.0	11.45	62.0	4.23
1036	8.0	9.0	11.57	61.0	4.22
1037	8.0	0.0	7.05	70.0	4.24
1038	32.0	0.0	28.21	46.0	4.26
1040	12.0	8.0	14.60	58.0	4.23
1041	8.0	2.0	8.06	68.0	4.24
1042	32.0	2.0	29.22	44.0	4.25
1045	8.0	10.0	12.08	60.0	4.22
1046	32.0	10.0	33.24	36.0	4.23
1048	7.0	12.0	12.20	59.0	4.21
1049	31.0	12.0	23.36	35.0	4.23
1050	12.0	2.0	11.59	64.0	4.24
1051	14.0	2.0	13.35	62.0	4.24
1052	16.0	2.0	15.11	60.0	4.24
1053	12.0	4.0	12.59	62.0	4.24
1054	32.0	4.0	30.22	42.0	4.25
1055	24.0	0.0	21.15	54.0	4.25
1056	12.0	0.0	10.58	66.0	4.25
1058	24.0	2.0	22.16	52.0	4.25
1065	8.0	4.0	9.06	66.0	4.23
1066	24.0	4.0	23.25	50.0	4.24
1067	8.0	10.0	12.04	60.0	4.22
1068	32.0	10.0	33.23	36.0	4.23
1070	8.0	6.0	10.07	64.0	4.23
1071	24.0	6.0	24.17	48.0	4.24
1072	24.0	8.0	25.18	46.0	4.23
1075	8.0	8.0	11.07	62.0	4.22
1076	24.0	8.0	25.17	46.0	4.23
1081	10.0	8.0	12.84	60.0	4.22
1083	12.0	2.0	11.59	64.0	4.24
1084	10.0	2.0	9.82	66.0	4.24
1085	10.0	4.0	10.82	64.0	4.23
1090	24.0	3.0	22.66	51.0	4.25
1091	12.0	3.0	12.09	63.0	4.24
1092	8.0	7.0	10.57	63.0	4.23
1093	24.0	7.0	24.67	47.0	4.24
1094	8.0	8.0	11.07	62.0	4.22
1120	14.0	0.0	12.34	64.0	4.25
1121	14.0	2.0	13.35	62.0	4.24
1122	14.0	3.0	13.85	61.0	4.24
1134	12.0	5.0	13.09	61.0	4.23
1135	24.0	5.0	23.66	49.0	4.24
1145	14.0	4.0	14.35	60.0	4.24
1146	12.0	6.0	13.60	60.0	4.23
1147	24.0	6.0	24.17	48.0	4.24
1153	14.0	5.0	14.85	59.0	4.23
1162	12.0	8.0	14.62	58.0	4.23
1163	24.0	8.0	25.21	46.0	4.23
1164	14.0	8.0	16.38	56.0	4.23

In addition to the constituents listed above, the following were present in all rations, with 2 exceptions.

Lard %	Cod liver oil %	Salt mixture %	Cellulose %
12.5	2.5	4	3

The exceptions mentioned above are Rations 957 and 958, which contained no lard.

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING

	Weights							
Weeks	Rat 2911 M	Food	Rat 2912 M	Food	Rat 2913 M	Food	Rat 2915 M	Food
				*50 mg. F_2**				*50 mg. F_2*
		Ration 961				*Ration 962*		
0	52		50		50		50	
1	65	54.88	64	55.12	52	24.40	64	36.46
2	80	61.55	79	58.63	70	37.92	82	38.80
3	83	57.02	79	43.74	79	44.06	95	42.59
4	92	59.52	83	46.65	91	45.72	105	41.54
5	92	51.99	87	46.26	94	39.87	114	51.40
				100 mg. F_2				*100 mg. F_2*
6	97	44.78	84	31.68	106	44.11	136	50.25
7	92	34.82	84	34.32	110	40.92	143	46.82
				250 mg. F_2				*250 mg. F_2*
		Ration 1035						
8	110	63.79	105	58.91	117	43.89	156	58.59
9	118	61.86	114	57.94	102	29.95	168	72.04
10	120	55.39	116	54.47	102	26.09	182	74.27
11	114	54.39	113	49.74	104	39.99	185	65.44
		Ration 1045				*Ration 1046*		
12	135	80.94	140	82.15	134	62.61	203	87.12
13	154	83.67	145	72.43	160	72.31	204	68.10
14	158	74.59	154	63.57	162	59.41	206	67.77
15	172	88.91	166	73.32	162	52.55	209	64.37
16	176	88.90	168	61.88	168	48.92	215	66.55
17	181	72.86	174	72.25	168	47.27	208	50.20
18	186	73.43	182	73.04	170	54.40	202	48.13
19	176	61.21	170	58.75	184	67.43	200	47.20
20	166	47.02	172	51.30	190	57.53	196	49.39

	Weights											
Weeks	Rat 3050 M	Food	Rat 3052 M	Food	Rat 3049 M	Food	Rat 3054 M	Food	Rat 3056 M	Food	Rat 3055 M	Food
			Ration 1037						*Ration 1038*			
0	47		47		49		50		47		49	
1	46	32.76	46	33.59	47	33.25	55	26.61	49	25.80	52	26.99
2	46	26.03	48	24.48	45	24.78	64	28.14	58	28.07	50	33.17
						50 mg. F_2						*50 mg. F_2*
			Ration 1041						*Ration 1042*			
3	52	40.43	57	42.63	56	41.53	85	56.00	73	41.71	83	50.50
4	52	35.45	57	38.20	61	48.17	101	62.05	82	48.36	100	58.58
5	52	28.23	58	29.81	64	36.87	112	49.65	88	37.93	112	49.44
						250 mg. F_2						*250 mg. F_2*
			Ration 1050									
6	59	30.57	72	43.59	85	52.99	123	55.68	98	40.26	138	62.70
			Ration 1051									
7	59	24.14	76	35.24	104	63.30	134	62.14	101	35.67	159	69.26
			Ration 1052									
8	59	26.52	79	34.23	122	56.57	134	54.34	106	35.40	176	60.08
			Ration 1053						*Ration 1054*			
9	82	54.24	105	63.73	140	71.00	158	71.19	120	47.04	192	68.91
10	88	44.08	119	59.80	145	52.80	170	62.77	136	53.14	200	59.76
11	94	48.47	123	59.29	149	56.21	180	61.81	143	43.72	206	59.48
12	96	37.03	130	55.67	163	70.96	195	66.31	155	53.75	220	65.88
13	98	40.60	132	45.45	167	55.10	192	50.57	168	57.46	226	70.84
14	109	51.84	152	73.20	180	83.31	204	80.52	170	61.58	238	82.19
15	122	50.79	176	79.96	202	82.12	217	76.50	187	68.56	254	75.98
16	126	50.61	180	80.22	212	89.53	225	75.86	198	72.57	258	72.67
17	130	55.26	184	76.96	208	69.53	222	67.46	208	70.45	268	82.65
18	138	58.65	192	81.62	208	79.12	224	84.04	209	73.54	264	83.32
19	166	83.41	204	79.49	204	67.37	227	76.76	226	83.80	264	77.97
20	187	82.25	222	77.84	220	77.05	240	70.35	242	78.40	270	71.77
21	185	71.79	224	83.46	221	73.13	234	66.57	243	80.03	274	78.13
22	196	75.02	224	71.43	214	56.09	234	64.36	252	77.94	278	75.19
23	195	63.16	230	78.57	216	77.00	232	66.43	248	79.62	278	70.90

*The Osborne-Wakeman fraction is designated as F_2.

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING (Continued)

Weeks	Weights							
	Rat 3341 M	Food	Rat 3339 M	Food	Rat 3342 M	Food	Rat 3343 M	Food
		Ration 1037				*Ration 1055*		
0	40		38		40		40	
1	35	25.06	35	25.61	37	14.51	34	18.32
				250 mg. F_2				*250 mg. F_2*
		Ration 1041				*Ration 1058*		
2	38	31.47	40	29.53	45	26.62	55	41.03
3	35	22.25	38	22.97	48	30.88	58	39.48
		Ration 1065				*Ration 1066*		
4	39	27.09	47	33.05	50	24.80	68	38.26
5	29	16.61	52	48.60	50	37.21	65	42.17
		Ration 1070				*Ration 1071*		
6	42	37.63	66	59.85	84	59.95	108	67.07
7	47	35.04	74	54.21	105	67.37	117	61.26
8	52	36.72	78	50.99	122	77.14	126	53.69
9	59	48.39	92	61.95	135	83.43	134	62.64
10	64	46.64	105	82.51	152	81.61	157	74.09
11	65	40.13	104	50.40	172	77.00	168	57.67
		Ration 1075				*Ration 1076*		
12	65	42.26	107	59.05	185	83.91	182	66.27
		Ration 1081						
13	79	51.34	121	67.10	194	83.26	182	80.50
14	90	60.68	130	61.60	195	84.28	178	63.26
15	99	57.78	130	57.85	214	86.75	184	63.82
16	100	64.45	140	72.45	216	83.08	178	69.62
17	116	60.46	150	71.28	220	78.67	186	66.57
18	116	66.54	150	57.28	220	78.63	192	68.62
19	115	64.75	148	68.95	218	76.81	200	81.69
20	120	66.33	150	67.21	220	81.99	203	88.49
21	121	71.05	150	89.05	223	89.46	205	88.01
22	125	62.61	159	86.01	232	86.52	213	82.72
23	139	81.26	169	75.38	236	87.69	220	83.58
24	142	65.12	164	62.25	237	79.96	221	88.16
25	136	62.24	164	71.97	234	82.81	220	74.87

Weeks	Weights							
	Rat 3357 M	Food	Rat 3356 M	Food	Rat 3359 M	Food	Rat 3363 M	Food
		Ration 1037				*Ration 1055*		
0	40		38		38		37	
1	40	24.41	38	23.10	40	20.41	38	21.22
				250 mg. F_2				*250 mg. F_2*
		Ration 1041				*Ration 1058*		
2	48	36.33	38	23.17	50	31.71	44	24.24
3	47	28.12	43	23.38	56	27.83	60	37.08
		Ration 1065				*Ration 1066*		
4	57	41.08	52	48.03	65	38.96	80	57.03
5	74	59.25	60	43.09	88	51.30	130	81.09
6	74	42.03	66	40.51	99	56.76	148	84.54
7	78	53.71	75	42.90	112	52.71	157	80.37
8	85	66.48	86	65.35	119	62.59	170	96.49
9	96	81.17	93	52.82	136	61.82	188	85.36
10	98	42.88	94	52.05	140	46.76	204	72.69
		Ration 1070				*Ration 1071*		
11	102	53.66	100	55.70	140	49.32	210	79.49
12	114	50.64	114	57.14	156	64.71	224	71.93
13	117	60.60	124	74.51	168	65.54	230	81.56
14	122	68.23	138	80.41	184	79.05	236	79.98
15	126	68.02	142	80.74	194	78.12	232	82.71
16	138	68.31	148	76.78	204	76.34	232	70.85
17	142	59.33	152	71.46	216	81.16	232	67.06
18	138	62.60	154	79.19	212	77.78	226	83.48
		Ration 1092				*Ration 1093*		
19	142	65.73	158	78.28	216	83.59	223	77.32
20	148	66.38	167	87.23	225	101.11	220	92.40
21	150	69.34	170	77.04	228	96.04	224	75.57
22	157	84.45	183	83.27	227	77.97	222	79.72
23	166	86.35	176	83.31	215	75.63	222	85.29
24	170	78.46	180	74.04	215	72.58	216	67.18
25	163	80.03	185	79.50	218	72.49	210	62.40

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING (Continued)

	Weights							
Week	Rat 3607 M	Food	Rat 3606 M	Food	Rat 3612 M	Food	Rat 3608 M	Food
		Ration 1037				*Ration 1055*		
0	34		33		36		34	
1	34	28.67	32	28.40	39	30.37	34	17.05
				250 mg. F_2				*250 mg. F_2*
		Ration 1041				*Ration 1058*		
2	38	30.14	32	17.76	52	24.78	62	39.68
		Ration 1084						
3	38	17.79	32	20.84	54	35.69	75	44.06
		Ration 1085						
4	46	32.04	36	24.20	66	38.77	108	71.45
5	50	33.89	36	25.42	74	33.02	140	72.38
		Ration 1083						
6	52	29.22	50	36.96	76	39.71	160	87.70
7	55	38.42	69	52.08	82	36.77	176	84.22
8	56	32.47	82	57.86	82	39.46	184	79.64
9	53	28.40	100	68.88	93	36.64	197	83.43
10	50	31.96	112	67.81	98	44.76	200	91.07
		Ration 1091				*Ration 1090*		
11	53	32.80	120	65.38	104	50.16	199	89.31
12	66	45.37	136	75.45	111	53.65	211	91.10
13	83	53.37	155	89.62	125	61.45	221	88.94
14	93	59.38	159	81.48	135	60.56	228	83.62
15	101	56.52	159	71.49	141	71.69	231	82.46
16	106	55.77	161	65.44	157	66.81	239	84.94
17	118	55.72	167	66.18	162	70.52	242	82.74
18	125	61.73	180	77.27	170	69.62	251	81.43
19	138	57.18	175	65.46	188	71.76	254	76.70
20	139	55.66	189	71.93	194	72.39	263	82.96
21	147	57.51	197	74.42	201	71.98	263	74.43
22	151	50.38	197	62.31	214	70.03	255	67.05
23 pt.	152	6.50	195	8.05	215	9.55	255	10.35
		Ration 1053				*Ration 1066*		
23 pt.	155	46.78	195	60.48	221	61.95	255	60.00
24 pt.	160	24.60	196	28.10	221	31.10	254	31.90
		Ration 1134				*Ration 1135*		
24 pt.	164	34.06	197	36.20	226	43.76	256	41.75
25	170	61.66	192	63.56	228	73.53	256	74.93

	Weights							
Weeks	Rat 226 M	Food	Rat 225 M	Food	Rat 227 M	Food	Rat 228 M	Food
		Ration 1056				*Ration 1055*		
0	32		30		32		31	
1	30	22.67	30	22.58	34	22.57	32	20.19
				250 mg. F_2				*250 mg. F*
		Ration 1083				*Ration 1058*		
2	43	33.94	35	25.42	48	31.82	54	35.57
3	50	34.68	40	22.08	60	35.18	68	38.91
4	53	30.93	47	35.31	66	35.38	99	63.24
5	60	35.48	58	32.61	80	42.15	116	61.24
6	66	39.42	68	43.54	90	43.53	130	63.27
7	76	49.21	82	56.61	102	47.78	148	82.22
8	80	47.53	97	55.84	105	46.75	154	80.98
9	81	45.67	106	61.90	111	47.74	167	75.13
10	86	43.80	119	61.70	127	50.43	187	83.00
11	90	46.02	124	67.34	133	53.97	198	91.61
12	92	40.59	130	58.39	142	50.23	202	74.79
13	93	42.76	130	56.33	147	54.51	203	77.90
14	94	45.22	135	53.30	154	52.15	211	70.32
15	93	29.48	135	48.82	160	53.30	207	66.47
		Ration 1091				*Ration 1090*		
16	99	40.04	143	54.98	172	57.73	222	69.02
17	110	41.50	144	44.59	186	58.60	230	68.28
18	112	42.81	140	41.01	188	55.60	226	58.60
19	112	35.08	148	44.19	188	55.99	232	60.08
20 pt.	115	5.00	150	6.55	199	8.50	232	8.05
		Ration 1053				*Ration 1066*		
20 pt.	119	35.33	142	23.84	202	47.31	235	54.98
21	123	40.51	143	41.07	208	58.36	238	69.14
22 pt.	126	28.76	144	29.28	211	44.98	235	46.55
		Ration 1134				*Ration 1135*		
22 pt.	130	12.00	147	12.43	220	18.26	245	17.30
23	131	40.60	143	41.30	227	67.33	239	60.20
		Ration 1146				*Ration 1147*		
24	134	41.73	148	46.15	233	69.70	236	59.27
25	122	32.28	140	32.91	240	70.56	233	65.16

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING (Continued).

Weeks	Weights Rat 229 M	Food	Rat 230 M	Food	Rat 231 M	Food	Rat 232 M	Food
		Ration 1056				*Ration 1055*		
0	33		32		32		30	
1	36	31.66	32	25.48	32	21.42	29	17.36
				250 mg. F_2				*250 mg. F_2*
		Ratin 1083				*Ration 1058*		
2	42	32.78	40	30.80	44	30.99	46	30.77
3	42	25.00	44	29.76	52	32.18	57	35.25
		Ration 1053				*Ration 1066*		
4	46	34.66	50	36.80	56	34.78	74	47.70
5	55	33.92	55	34.56	64	39.72	94	52.45
6	56	37.24	56	29.79	76	43.78	110	58.07
7	72	52.49	70	49.81	92	45.87	134	70.17
8	87	55.08	82	53.66	108	52.52	130	59.15
9	95	56.92	94	50.77	116	53.91	146	66.69
10	90	43.18	98	47.42	133	62.07	153	72.81
11	104	49.92	106	59.48	142	73.13	172	78.81
12	120	64.43	115	53.34	157	61.94	185	73.75
13	116	48.93	109	47.35	149	62.13	193	71.78
14	119	50.14	110	46.17	155	55.16	200	75.31
15	120	54.27	118	49.91	172	73.05	201	73.26
16	120	48.05	121	47.16	179	71.72	211	68.94
17	129	54.55	124	40.45	185	62.29	214	74.85
18	128	40.66	120	35.11	184	57.59	220	65.48
19	137	46.94	129	45.31	185	52.31	230	62.32
20	142	48.93	140	48.98	177	41.96	228	54.99
21	149	58.98	144	49.33	176	52.75	222	58.62
		Ration 1134				*Ration 1135*		
22	154	48.13	156	54.31	188	54.93	228	58.36
23	150	45.03	154	48.96	183	50.08	219	51.66
		Ration 1146				*Ration 1147*		
24	154	54.78	159	60.93	184	51.53	220	57.55
25	159	50.22	160	50.26	182	57.36	209	49.60

Weeks	Weights Rat 255 M	Food	Rat 254 M	Food	Rat 259 M	Food	Rat 256 M	Food
		Ration 1056				*Ration 1055*		
0	36		34		36		34	
1	44	26.79	35	20.15	42	20.82	34	16.28
2	42	24.30	34	22.76	40	19.39	34	18.78
				250 mg. F_2				*250 mg. F_2*
		Ration 1083				*Ration 1058*		
3	56	40.89	59	49.23	62	32.05	62	41.03
4	62	39.87	60	35.86	64	36.99	70	36.92
5	74	44.16	74	53.45	72	36.15	80	42.69
6	88	48.98	90	56.74	73	34.77	107	59.23
7	93	46.13	104	57.98	80	31.42	140	70.09
8	100	44.90	113	55.75	94	44.39	163	74.68
9	112	50.91	128	66.41	100	46.52	180	78.80
10	117	49.82	136	58.35	112	41.20	206	77.31
11	120	49.36	142	56.75	120	42.77	214	74.56
12	130	48.33	148	56.72	134	45.59	218	66.04
13	127	44.31	154	52.44	145	48.74	220	58.90
14	132	48.13	152	52.91	146	45.48	232	66.09
15	130	39.50	156	53.80	160	51.78	244	63.10
16 pt.	137	4.10	155	7.15	160	6.38	242	5.80
		Ration 1091				*Ration 1090*		
16 pt.	140	45.63	166	51.28	164	44.01	246	54.35
17	154	60.18	180	67.54	181	52.34	248	53.98
18 pt.	154	7.88	187	9.65	183	7.10	248	8.20
		Ration 1053				*Ration 1066*		
18 pt.	159	50.68	188	56.61	198	57.60	254	57.91
19	160	59.79	192	60.18	217	69.15	261	63.77
20	174	62.35	207	76.70	234	72.86	270	69.61
21	176	58.61	214	71.40	237	62.30	272	64.55
22 pt.	174	41.91	211	47.45	236	50.25	268	44.76
		Ration 1146				*Ration 1147*		
22 pt.	176	16.25	216	20.58	244	23.50	269	19.65
23	178	44.26	216	60.13	254	78.23	270	63.38
24	183	51.06	219	60.71	259	74.14	270	60.38
25	182	50.98	220	58.93	267	67.59	272	63.34

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING (Continued)

	Weights							
Weeks	Rat 3717 M	Food	Rat 3716 M	Food	Rat 3719 M	Food	Rat 3721 M	Food
		Ration 1056				*Ration 1055*		
0	36		32		37		34	
1	36	27.14	29	22.63	36	18.06	29	15.74
				250 mg. F_2				*250 mg. F_2*
		Ration 1083				*Ration 1058*		
2	42	31.10	52	43.63	45	30.35	48	29.10
3	42	34.51	66	51.89	45	31.81	72	53.80
		Ration 1091				*Ration 1090*		
4	47	33.72	80	61.54	51	36.23	89	59.06
5	51	35.76	100	76.85	53	34.78	124	89.34
6	58	34.15	119	76.66	57	31.74	148	88.03
7	66	36.58	131	76.91	64	38.08	181	97.38
8	69	35.96	135	66.79	69	36.72	189	83.44
9	72	37.03	133	65.04	68	37.51	190	76.02
10	83	40.54	143	65.29	73	32.12	205	77.65
11	88	39.85	150	60.04	74	40.43	208	80.35
12	96	40.68	158	59.65	80	40.04	212	83.47
13	98	41.42	157	57.44	85	37.36	220	67.47
14 pt.	100	12.48	156	16.58	87	11.20	222	21.25
		Ration 1053				*Ration 1066*		
14 pt.	106	29.58	162	42.10	94	28.21	228	52.20
15	113	44.14	168	57.75	100	38.53	236	67.71
16	123	51.04	174	56.78	109	43.71	248	74.53
17	132	52.97	179	68.23	116	43.61	244	67.50
18	140	55.41	186	73.91	118	38.41	251	66.91
19	148	57.04	196	72.14	128	49.51	252	67.98
20	147	49.29	188	65.86	124	39.21	244	56.35
		Ration 1146				*Ration 1147*		
21	157	55.93	192	63.14	132	44.99	248	67.38
22	168	55.73	197	65.73	133	41.96	250	66.73
23	182	59.53	198	64.11	138	41.60	256	66.39
24	179	56.41	196	63.79	146	48.56	251	62.10
25	187	68.21	201	69.31	154	62.46	241	64.48

	Weights							
Weeks	Rat 3718 M	Food	Rat 3715 M	Food	Rat 3720 M	Food	Rat 3722 M	Food
		Ration 1056				*Ration 1055*		
0	40		35		38		33	
1	42	34.88	35	21.59	37	18.60	29	16.30
				250 mg. F_2				*250 mg. F_2*
		Ration 1083				*Ration 1058*		
2	49	41.05	44	34.40	45	38.12	58	45.92
3	47	35.26	52	34.56	50	36.29	78	62.08
4	51	38.70	57	43.13	54	30.45	93	65.45
5	52	34.82	60	55.09	53	26.54	106	56.75
		Ration 1091				*Ration 1090*		
6	61	37.14	82	56.51	58	34.88	127	70.20
7	74	51.95	98	71.73	74	45.25	134	68.02
8	82	47.21	113	70.84	93	51.91	150	72.89
9	84	47.24	119	71.66	99	56.87	154	70.35
10	93	44.25	127	68.07	122	55.38	170	67.88
11	96	41.65	136	63.26	126	54.43	176	76.68
12	104	46.52	150	61.14	137	48.34	190	74.41
13	107	36.41	156	65.46	140	46.16	196	74.75
		Ration 1053				*Ration 1066*		
14	112	45.30	161	60.46	146	57.16	205	70.83
15	126	45.01	170	59.49	158	54.01	216	73.40
16	136	59.06	173	55.73	172	65.11	224	74.01
17	146	64.23	190	69.98	187	63.53	217	51.66
18	165	75.73	205	81.01	194	63.66	227	75.93
19	172	68.51	213	80.20	199	61.43	242	85.74
20 pt.	172	40.63	215	55.56	196	39.23	235	50.58
		Ration 1146				*Ration 1147*		
20 pt.	174	19.95	216	20.65	200	18.45	244	24.60
21	183	54.30	220	70.80	207	52.67	247	69.08
22	192	71.40	220	62.95	216	67.16	252	70.83
23	199	67.33	225	64.41	225	67.35	261	69.20
24	196	74.89	215	58.78	220	61.89	238	56.24
25	201	69.60	209	59.19	226	73.11	242	81.78

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING (Continued)

	Weight							
Weeks	Rat 3781 M	Food	Rat 3780 M	Food	Rat 3786 M	Food	Rat 3784 M	Food
		Ration 1056				*Ration 1055*		
0	36		36		34		34	
1	34	22.86	32	18.61	32	19.23	30	18.27
				250 mg. F_2				*250 mg. F_2*
		Ration 1083				*Ration 1058*		
2	40	35.28	45	41.01	33	23.42	47	30.19
3	41	29.58	67	60.49	34	20.91	76	60.96
4	43	29.13	77	57.62	34	23.51	82	61.26
		*Ration N-1091**				*Ration N-1090*		
5	46	30.14	80	44.83	43	26.09	96	54.58
6	43	26.73	90	49.56	50	27.07	116	61.32
		Ration N-1053				*Ration N-1066*		
7	44	24.84	100	51.48	64	38.31	148	83.65
8	52	30.08	107	51.51	78	41.45	178	90.72
9	52	31.36	112	52.69	86	37.93	192	73.20
10	50	24.78	116	46.68	89	31.35	214	80.83
11 pt.	48	11.67	120	23.61	95	25.03	228	60.38
		Ration N-1134				*Ration 1135*	*N-1135*	
11 pt.	52	5.78	126	15.03	99	10.00	231	20.18
12	47	20.26	128	49.41	106	36.07	230	73.36
13	53	29.28	131	47.36	120	43.56	232	76.66
14 pt.	60	31.67	134	47.60	131	39.13	239	76.83
						Ration N-1163		
14 pt.					133	5.25		
		Ration N-1162						
15	68	37.38	134	49.11	133	39.23	235	72.68
16	90	55.01	137	48.58	146	43.79	235	72.13
17	105	57.06	142	50.35	155	46.59	244	78.73
18	108	46.23	145	52.50	160	44.03	240	69.28
19	112	46.05	142	50.41	175	59.44	230	60.11
20	117	48.36	142	51.60	180	64.98	227	73.71
21	124	49.28	146	50.43	197	69.61	223	65.18
22	130	48.13	154	60.40	206	66.48	222	59.91
23	135	50.33	149	54.04	215	71.85	208	58.18
24	144	59.96	155	55.93	212	65.16	203	62.83
25	159	61.10	165	57.83	215	65.38	195	51.53

	Weights											
Weeks	Rat 350 M	Food	Rat 353 M	Food	Rat 352 M	Food	Rat 354 M	Food	Rat 355 M	Food	Rat 356 M	Food
		Ration 1056								*Ration 1055*		
0	36		34		32		34		35		32	
1	30	16.50	34	21.04	25	17.56	33	21.55	32	17.17	26	15.25
						250 mg. F_2						*250 mg. F_2*
		Ration 1083								*Ration 1058*		
2	36	24.38	35	22.70	40	21.92	42	27.61	36	21.28	42	32.84
3	35	17.86	40	25.36	41	31.59	48	25.91	43	21.65	73	50.48
		Ration N-1091								*Ration N-1090*		
4	47	26.56	54	36.99	45	27.91	49	33.31	54	30.56	92	62.24
5	51	25.78	60	39.27	52	28.99	62	36.21	70	37.45	123	61.79
6	64	38.73	94	48.29	61	32.71	64	28.37	77	32.89	147	63.94
7	74	40.89	104	46.11	74	38.25	75	33.45	89	36.68	160	71.14
8	81	35.21	120	48.52	76	30.49	82	27.63	98	34.94	179	73.01
9	90	37.00	131	54.28	78	33.00	88	30.50	112	39.40	202	70.21
10	92	34.97	147	65.06	78	27.31	88	29.95	122	52.34	208	61.30
		Ration N-1053								*Ration N-1066*		
11	97	29.19	152	48.21	93	35.21	107	35.16	133	35.55	219	52.61
12	109	47.48	149	55.61	99	46.23	119	43.55	142	50.66	226	62.86
13	119	47.99	149	52.35	107	48.43	132	50.35	152	53.10	234	65.39
14 pt.	127	43.43	156	42.75	112	37.29	144	42.60	156	40.63	245	44.45
		Ration N-1162								*Ration N-1163*		
14 pt.	128	7.90	156	7.95	113	7.55	138	3.55	156	8.10	243	8.35
15	129	47.56	168	62.33	122	52.66	150	57.08	158	52.51	227	51.35
16	137	46.66	181	65.40	128	50.18	167	65.40	158	46.53	232	58.23
17	150	56.24	186	58.41	138	52.00	148	38.43	161	49.53	219	39.11
18	154	46.63	186	55.56	143	46.00	173	56.51	166	49.08	205	41.31
19	152	50.17	190	62.23	146	50.56	173	55.51	158	45.66	196	45.61
20	159	50.23	197	61.88	149	50.20	179	58.13	165	56.68	202	59.40
21	161	58.56	197	65.00	146	53.13	184	64.13	162	48.95	190	45.11
22	158	46.58	199	64.51	152	54.35	187	57.66	163	51.35	199	55.67
23	162	56.80	205	70.18	152	49.15	203	70.99	163	51.98	198	51.53
24	165	53.63	207	61.81	157	55.06	197	55.89	165	51.45	201	53.01
25			214	64.65	164	54.70	205	64.58	170	53.58		

*The letter N preceding the ration number indicates that casein 180 was substituted for casein 80.

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING (Continued)

	Weights							
Weeks	Rat 3799 M	Food	Rat 3798 M	Food	Rat 3801 M	Food	Rat 3802 M	Food
		Ration 1056				*Ration 1055*		
0	37		36		32		32	
1	34	20.55	32	20.27	29	16.32	28	17.19
				250 mg. F_2				*250 mg.* F_2
		Ration 1083				*Ration 1058*		
2	38	30.34	50	42.05	34	25.59	42	36.13
3	42	28.23	64	46.03	30	24.66	57	43.28
4	45	29.16	73	55.92	38	28.67	90	62.71
5	48	29.47	77	43.30	40	28.37	115	64.88
		Ration N-1091				*Ration N-1090*		
6	50	24.77	89	45.64	44	24.20	135	60.32
7	53	29.21	94	33.58	50	23.49	150	61.21
8	55	27.95	100	41.08	57	25.10	158	57.09
		Ration N-1053				*Ration N-1066*		
9	55	20.03	102	35.21	58	22.51	163	46.76
10	58	27.89	110	43.53	76	28.04	153	35.28
		Ration N-1134				*Ration N-1135*		
11	61	26.55	116	37.26	77	24.73	180	58.13
12	69	33.60	122	44.35	83	30.03	200	67.95
13	66	24.04	129	42.49	92	29.58	209	60.19
14 pt.	68	14.53	132	25.25	99	17.95	216	35.28
		Ration N-1162				*Ration N-1163*		
14 pt.	66	10.50	132	19.60	98	14.55	210	20.05
15	71	30.38	133	41.09	107	36.26	212	55.93
16	81	38.74	136	42.35	122	45.62	220	57.71
17	95	49.18	141	46.18	133	46.91	216	48.93
18	104	47.63	151	52.68	135	26.29	212	47.52
19	105	46.72	147	45.98	137	47.01	210	56.56
20	112	46.95	144	47.99	147	54.73	202	53.20
21	115	49.93	145	53.83	151	51.84	204	55.26
22	117	46.70	140	38.59	153	51.63	196	49.79
23	124	51.56	150	57.88	153	50.41	192	50.29
24	124	47.15	154	58.19	158	55.26	195	55.61

	Weights							
Weeks	Rat 3927 M	Food	Rat 3928 M	Food	Rat 3932 M	Food	Rat 3931 M	Food
		Ration 1120				*Ration 1055*		
0	32		30		30		30	
1	32	27.98	30	22.65	28	11.54	26	15.46
				250 mg. F_2				*250 mg.* F_2
		Ration 1121				*Ration 1058*		
2	35	29.93	46	35.43	28	21.14	42	28.72
3	39	24.68	60	38.47	38	25.06	52	37.41
4	40	23.33	62	33.58	44	27.29	62	36.28
5 pt.	42	3.58	68	13.10	46	9.20	66	9.08
		Ration 1122				*Ration N-1090*		
5 pt.	44	21.90	76	28.40	48	19.17	74	34.55
6 pt.	46	21.02	82	37.08	52	22.25	90	38.79
		Ration N-1145				*Ration N-1066*		
6 pt.	46	4.00	86	5.75	60	6.28	92	8.00
7	50	34.07	100	51.45	72	35.92	104	55.27
		Ration N-1153				*Ration N-1135*		
8	52	30.83	112	47.98	86	35.41	124	54.60
9	62	41.31	128	64.23	104	49.97	138	61.95
10	66	45.26	144	73.06	114	51.91	146	58.65
11 pt.	70	13.51	152	18.40	119	17.08	150	18.18
		Ration N-1164				*Ration N-1163*		
11 pt.	82	33.48	152	43.06	132	37.74	152	46.85
12	97	49.96	154	56.60	135	61.95	157	59.18
13	102	52.10	156	49.80	138	45.49	155	50.51
14	104	46.99	158	49.84	140	45.51	154	50.33
15	114	60.75	160	58.74	136	51.55	154	60.83
16	118	57.99	174	68.60	138	51.19	156	57.88
17	128	58.93	182	70.43	142	48.98	162	54.93
18	136	69.04	182	73.24	150	60.23	166	62.41
19	142	62.81	188	67.74	150	51.29	168	59.09
20	152	62.80	200	71.42	158	59.49	176	64.50
21	154	64.84	201	69.96	160	54.62	180	58.50
22	160	63.69	200	59.23	164	54.71	182	53.86

TABLE 15.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); *Ad Libitum* FEEDING (Continued)

	Weights							
Weeks	Rat 3935 M	Food	Rat 3934 M	Food	Rat 3938 M	Food	Rat 3937 M	Food
		Ration 1120				*Ration 1055*		
0	44		45		44		46	
1	44	29.21	42	27.68	36	16.37	38	15.73
				250 mg. F_2				*250 mg. F_2*
		Ration 1121				*Ration 1058*		
2	54	36.80	52	28.04	45	23.75	62	35.98
3	58	33.68	52	25.93	52	30.86	74	46.94
4	59	30.57	70	31.33	53	30.88	92	51.75
		Ration N-1122				*Ration N-1090*		
5	66	28.73	76	26.98	62	21.85	120	43.13
6 pt.	70	34.42	84	29.17	68	27.56	148	50.33
		Ration N-1145				*Ration N-1066*		
6 pt.	70	4.20	88	5.30	68	4.50	150	9.20
7	72	47.70	94	43.59	80	36.98	156	67.91
		Ration N-1153				*Ration N-1135*		
8	82	44.13	118	50.52	88	35.58	168	51.79
9	94	53.60	128	51.58	106	51.91	174	65.86
10	104	56.86	144	64.64	118	52.90	188	63.14
11 pt.	106	15.30	148	17.25	126	19.30	194	23.60
		Ration N-1164				*Ration N-1163*		
11 pt.	102	41.63	152	44.01	140	49.60	209	60.23
12	109	44.20	158	56.21	152	64.25	214	82.20
13	116	45.00	164	51.36	162	64.58	226	74.45
14	120	46.77	176	51.55	164	58.52	228	66.88
15	124	52.93	166	47.82	168	71.46	224	72.20
16	132	59.51	168	50.55	164	66.25	232	77.22
17	142	44.68	170	43.08	188	71.03	238	75.22
18	144	57.77	166	45.67	198	83.25	229	75.49
19	154	58.45	168	42.42	200	71.37	232	72.10
20	164	65.45	188	57.15	212	78.31	232	63.82
21	168	59.54	192	55.81	206	60.58	228	57.76
22	166	44.47	192	50.67	192	45.48	221	52.87

TABLE 16.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS) REGULATED FEEDING

Weeks	Rat 2962 M	Food	Rat 2963 M	Food	Rat 2964 M	Food	Rat 2966 M	Food
	Weights							
		Ration 1009		*50 mg. F_2*		*Ration 1010*		*50 mg. F_2*
0	45		44		41		44	
1	55	34.65	51	33.68	56	33.44	61	33.46
2	67	47.37	65	48.47	82	49.48	87	48.69
3	74	49.58	74	49.06	95	48.31	101	48.95
				100 mg. F_2				*100 mg. F_2*
4	78	37.67	75	37.41	98	37.94	105	37.58
5	92	57.48	83	58.49	122	58.36	132	56.74
				250 mg. F_2				*250 mg. F_2*
6	100	55.63	98	56.66	145	54.19	153	54.25
7	99	48.48	98	45.77	152	48.26	160	49.11
8	112	56.47	105	57.19	160	54.45	166	53.64
9	118	57.48	110	58.81	163	60.31	168	59.91
10	117	57.54	121	58.87	164	57.18	174	61.03
11	130	66.45	131	66.07	182	66.94	187	64.87
12	132	66.82	134	66.16	192	66.84	199	66.44
13	140	66.49	138	66.52	202	66.61	208	66.00
14	144	66.98	143	66.07	210	67.75	220	67.43
15	147	55.01	144	53.83	212	54.86	222	54.77
16	147	52.55	144	53.40	211	52.31	218	51.85
17	144	45.25	142	50.15	210	46.96	215	49.09
18	147	47.68	140	43.93	204	47.52	214	45.33
19	142	54.42	138	53.27	212	53.03	208	54.94
20	140	55.00	140	54.81	210	55.30	205	52.90
		Ration 1067				*Ration 1068*		
21	146	53.37	146	52.34	212	53.52	207	52.98
22	150	62.26	150	62.52	220	60.39	205	62.62
23	154	60.52	152	60.75	217	62.21	198	62.25
24	150	56.39	153	56.54	210	50.79	190	54.18
25	150	50.78	150	50.74	213	50.85	192	52.29

Weeks	Rat 221 M	Food	Rat 222 M	Food	Rat 223 M	Food	Rat 224 M	Food
	Weights							
		Ration 1009		*250 mg. F_2*		*Ration 1072*		*250 mg. F_2*
0	30		30		33		30	
1	37	27.78	36	25.76	46	28.46	48	29.95
2	46	28.45	42	26.24	60	27.55	62	26.71
3	52	27.44	52	32.46	68	28.60	73	28.86
4	65	39.18	65	37.09	84	38.84	86	37.47
5	64	26.04	68	27.93	87	27.81	90	27.81
6	68	36.63	72	36.50	92	36.45	100	36.37
7	77	35.91	77	34.83	100	34.86	102	34.80
8	82	39.81	88	40.73	112	38.76	118	39.84
9	92	42.36	90	39.63	120	41.84	128	40.80
		Ration 1094						
10	100	43.42	95	42.31	128	43.83	137	43.77
11	103	45.04	103	42.55	133	41.83	140	41.74
12	106	43.24	108	43.34	139	42.84	145	42.80
13	119	58.81	121	59.34	164	63.82	163	62.55
14	120	44.58	123	47.09	163	44.53	166	43.70
15	130	43.60	130	39.29	152	25.77	154	38.79
16	128	32.85	136	38.12	165	56.59	164	39.03
17	136	50.21	145	47.52	159	44.42	174	46.73
18 pt.	140	26.10	146	24.78	164	23.88	170	24.89
		Ration 1040						
18 pt.	150	27.82	158	24.96	168	25.07	184	25.60
19	164	39.90	172	41.34	172	43.40	192	42.59
20	168	50.70	180	50.85	181	51.70	204	51.66
21	166	42.51	176	42.96	188	40.74	204	41.63
22	178	58.86	186	59.29	196	58.32	205	57.66
23	178	52.28	194	51.99	200	52.65	216	53.56
24	188	47.03	197	44.04	210	47.62	228	46.60
25	184	47.84	194	51.65	208	46.82	222	46.84

TABLE 16.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); REGULATED FEEDING (Continued)

Weeks	Weights Rat 3550 M	Food	Rat 3551 M	Food	Rat 3552 M	Food	Rat 3545 M	Food
		Ration 1009		*250 mg. F_2*		*Ration 1072*		*250 mg. F_2*
0	37		38		37		36	
1	40	34.26	42	35.53	44	34.11	44	33.81
2	50	35.98	52	34.29	60	35.94	64	36.82
3	58	41.13	62	41.14	80	41.71	80	40.72
4	58	40.23	66	42.06	82	41.41	88	41.03
5	58	32.58	68	31.85	92	33.60	98	33.68
6	62	36.46	74	36.22	92	34.83	102	36.78
7	62	33.15	77	32.31	98	31.55	106	31.71
8	68	43.51	84	43.10	112	43.46	114	42.76
9	74	45.76	98	45.57	124	45.77	130	44.82
10	78	43.33	103	43.29	134	43.79	143	43.72
11	76	36.39	99	36.45	132	36.72	138	37.76
		Ration 1094						
12	78	39.43	102	40.10	134	40.82	138	40.71
13	80	43.82	108	43.94	140	43.85	146	43.78
14	84	42.47	110	42.50	142	40.85	150	41.83
15	82	37.41	112	37.41	139	38.76	145	37.86
16	89	43.86	119	43.37	144	42.68	154	42.72
17	88	35.94	116	37.36	147	37.75	150	37.76
18	79	33.11	118	28.15	150	32.85	149	32.83
19	84	33.10	122	37.82	152	33.85	159	33.68
20	85	35.08	117	33.38	147	32.32	153	33.31
21 pt.	82	4.64	122	6.48	152	6.85	160	6.82
		Ration 1040						
21 pt.	94	44.05	140	45.87	170	44.77	174	45.61
22	106	46.22	148	41.82	180	44.52	184	44.14
23	109	47.92	148	46.56	181	44.64	182	44.57
24	119	46.20	152	47.02	192	48.38	193	46.40
25	126	59.17	170	62.32	207	64.37	209	63.70

Weeks	Weights Rat 2770 M	Food	Rat 2772 M	Food	Rat 2773 M	Food	Rat 2775 M	Food
		Ration 957		*50 mg. F_2*		*Ration 958*		*50 mg. F_2*
0	38		37		38		37	
1	44	29.25	43	29.30	48	29.45	48	29.79
2	57	37.60	55	37.58	68	37.49	66	37.46
3	70	44.30	70	45.23	84	45.03	84	44.88
4	72	48.68	75	48.04	101	48.48	100	47.82
				100 mg. F_2				*100 mg. F_2*
5	79	42.27	85	43.25	109	42.38	112	43.38
6	88	49.36	90	47.73	120	48.18	125	47.61
7	88	39.19	92	39.52	124	38.21	128	39.37
8	93	38.83	95	39.63	121	38.52	127	39.34
9	98	37.43	98	38.31	128	40.62	133	40.93
10	93	36.50	95	35.28	115	31.57	124	34.25
				200 mg. F_2				*200 mg. F_2*
11	95	40.10	94	40.29	116	43.80	123	40.34
				150 mg. F_2				*150 mg. F_2*
12	99	50.90	98	50.22	127	49.31	134	49.93
13	109	47.21	110	47.65	143	49.61	148	48.23
				250 mg. F_2				*250 mg. F_2*
14	120	57.86	122	58.31	152	57.08	165	58.08
15	125	61.62	125	57.84	146	57.17	168	57.71
16	122	44.95	120	48.64	147	48.32	164	49.48
17 pt.	122	16.22	118	12.86	142	9.15	162	12.83
		Ration 1043				*Ration 1044*		
17 pt.	127	39.34	126	38.17	147	38.05	171	38.47
18	127	57.82	129	59.58	146	60.69	166	59.30
19	142	67.08	142	67.03	156	65.80	180	67.09
20	142	57.49	147	57.88	155	56.92	185	57.83
21	144	60.31	143	56.95	153	57.23	184	56.20
22	132	48.52	136	53.13	156	53.91	184	53.38
23	125	37.57	124	33.72	144	33.86	170	34.64
24	127	46.88	138	48.90	148	47.50	172	47.93
25	136	57.92	150	56.27	160	57.81	188	57.35

TABLE 16.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); REGULATED FEEDING (Continued)

Weeks	Weights							
	Rat 2752 F	Food	Rat 2754 F	Food	Rat 2756 F	Food	Rat 2757 F	Food
				50 mg. F_2				*50 mg. F_2*
		Ration 959				*Ration 960*		
0	35		38		37		34	
1	39	27.06	43	27.13	51	27.11	41	24.69
2	54	38.14	57	38.14	72	38.48	62	40.47
3	64	47.63	69	47.80	90	47.79	83	47.77
				100 mg. F_2				*100 mg. F_2*
4	74	53.46	80	53.06	98	52.87	100	53.14
5	83	50.50	88	51.11	108	49.09	111	50.48
6 pt.	79	28.78	83	27.81	100	26.77	109	29.48
		Ration 961				*Ration 962*		
6 pt.	81	5.97	86	5.96	103	4.99	110	5.88
7 pt.	80	18.82	85	18.80	105	17.87	111	18.77
		Ration 968				*Ration 969*		
7 pt.	82	15.86	85	15.89	110	14.96	113	15.88
8	89	46.59	93	45.99	119	47.16	126	46.04
9	101	55.42	109	55.07	137	54.81	143	55.05
10	106	60.80	117	62.11	150	62.14	158	61.92
11	106	61.36	114	59.93	158	59.77	158	60.39
12pt.	102	14.67	112	15.02	154	15.82	156	15.87
				200 mg. F_2				*200 mg. F_2*
		Ration 1019				*Ration 1020*		
12 pt.	102	35.76	107	36.76	152	36.13	155	36.70
				250 mg. F_2				*250 mg. F_2*
13	116	62.63	125	62.40	158	58.28	165	59.30
14	114	48.71	122	45.27	154	52.10	158	51.60
15	111	40.89	121	45.21	153	40.24	154	40.29
16	112	51.55	124	52.91	154	53.06	154	53.16
17 pt.	115	17.53	126	16.50	158	18.57	158	16.95
		Ration 1045				*Ration 1046*		
17 pt.	114	33.90	126	34.21	149	30.22	158	36.39
18	114	48.52	126	48.78	149	50.57	154	46.53
		Ration 1048				*Ration 1049*		
19	129	62.89	144	63.26	158	62.78	172	63.24
20	130	55.12	142	54.05	159	52.06	165	55.43
21	133	54.00	137	55.01	158	55.03	162	53.43
22	136	52.21	140	51.58	163	55.28	168	52.54
23	142	56.12	148	54.13	162	54.09	162	55.63
24	143	47.79	153	50.10	164	49.11	164	48.35
25	137	42.98	148	43.32	160	45.04	158	42.68

Weeks	Weights							
	Rat 2765 F	Food	Rat 2766 F	Food	Rat 2768 F	Food	Rat 2769 F	Food
				50 mg. F_2				*50 mg. F_2*
		Ration 961				*Ration 962*		
0	42		44		43		40	
1	49	36.15	52	36.19	57	36.24	57	36.20
2	62	46.33	62	46.50	80	46.70	76	46.26
3	73	50.62	75	50.28	94	50.02	89	50.41
				100 mg. F_2				*100 mg. F_2*
4	88	56.82	90	56.74	113	56.90	112	56.87
5	98	51.47	98	51.39	125	50.92	123	51.03
6	98	43.61	98	44.14	125	44.03	125	44.51
7	102	43.65	109	43.70	126	41.16	130	43.72
8	92	28.31	97	28.32	116	31.81	121	28.31
9	89	23.22	101	28.81	115	22.62	119	26.54
		Ration 1009				*Ration 1010*		
10	80	20.45	98	30.84	108	30.13	117	31.81
11	85	34.53	94	29.87	106	29.67	108	29.73
12	91	44.76	101	38.80	111	39.26	121	38.26
				250 mg. F_2				*250 mg. F_2*
13	99	44.53	110	44.54	128	46.87	130	44.63
14	104	50.89	118	50.72	125	46.03	136	51.15
15	111	52.64	125	51.10	137	57.50	146	51.50
16	114	52.44	126	54.19	138	50.96	148	53.19
17 pt.	116	19.43	128	19.89	140	19.92	154	18.92
		Ration 1045				*Ration 1046*		
17 pt.	121	42.22	139	42.35	150	42.40	162	42.70
18	116	50.68	134	52.62	143	52.68	150	52.46
		Ration 1048				*Ration 1049*		
19	125	59.12	142	62.25	154	62.91	158	62.91
20	130	59.39	146	56.52	152	55.62	155	55.39
21	133	62.63	140	60.87	157	63.65	164	64.29
22	127	52.42	148	54.51	157	51.76	168	51.53
23	130	51.92	146	50.51	155	50.76	168	50.58
24	130	51.77	152	55.23	160	55.00	170	54.93
25	130	53.87	155	53.06	160	50.74	168	50.43

TABLE 16.—WEIGHTS OF INDIVIDUAL RATS, AND OF THE AMOUNTS OF FOOD CONSUMED (IN GRAMS); REGULATED FEEDING (Continued)

	Weights							
Weeks	Rat 2781 F	Food	Rat 2778 F	Food	Rat 2777 F	Food	Rat 2776 F	Food
		Ration 968		*50 mg. F_2*		*Ration 969*		*50 mg. F_2*
0	42		41		39		39	
1	45	36.17	42	34.45	54	35.99	54	35.24
2	52	42.17	49	42.25	70	42.12	72	43.15
				100 mg. F_2				*100 mg. F_2*
3	59	41.64	56	43.27	80	41.88	83	41.18
4	61	40.07	59	40.19	95	39.99	94	40.67
5	66	40.36	64	40.91	98	40.62	98	39.93
6	68	40.46	67	39.90	106	40.20	107	40.07
7	68	39.71	68	39.84	111	40.78	110	41.23
8	74	40.25	72	40.40	113	38.17	116	38.03
9	74	39.33	72	39.34	117	41.74	120	41.31
10	74	41.65	72	41.72	118	40.80	120	41.36
11ft.	72	12.29	72	12.52	120	12.84	122	12.64
		Ration 1019				*Ration 1020*		
11 pt.	72	29.06	74	29.69	119	30.86	123	30.19
				200 mg. F_2				*200 mg. F_2*
12	80	36.65	82	35.22	122	35.54	122	36.21
13	72	25.52	74	32.70	118	30.69	118	30.81
		Ration 1036						
14	74	35.71	79	37.12	118	36.48	118	36.19
15	86	42.10	94	43.98	120	42.93	120	43.26
16	77	26.18	88	29.91	118	33.68	116	33.47
17	76	42.69	88	37.91	107	33.54	110	33.30
		Ration 1048				*Ration 1049*		
18	96	56.10	106	52.43	126	56.72	134	56.31
19	104	50.29	110	53.49	130	50.34	138	50.35
20	108	54.00	114	54.29	128	45.50	146	53.45
21	106	43.63	114	46.40	130	50.14	144	42.50
22	110	50.75	115	47.46	136	51.99	148	51.29
23	110	41.82	118	43.85	136	44.23	152	45.19
24	114	48.45	124	47.00	138	46.15	155	46.57
25	114	48.32	124	50.03	142	49.21	156	48.53