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**RECOMMENDED DIETARY  
ALLOWANCES**

**REVISED 1945**

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# RECOMMENDED DIETARY ALLOWANCES

REVISED 1945

FOOD AND NUTRITION BOARD  
NATIONAL RESEARCH COUNCIL  
2101 CONSTITUTION AVENUE  
WASHINGTON 25, D. C.

# RECOMMENDED DIETARY ALLOWANCES

REVISED 1945

Food and Nutrition Board, National Research Council

Dietary standards serve as a measure in planning diets and food supplies. Standards have existed for many years. They change from time to time as knowledge increases and no standard can be considered as final. The standards formulated by the League of Nations in 1935 were the result of a concerted group effort and were based on information then at hand. As research continued, numerous new standards were suggested by individuals and groups; these varied widely in completeness and in amounts of individual essentials. The range in recommended amounts was so great that a generally acceptable set of standards became impossible to develop by individual effort.

The Food and Nutrition Board was organized late in 1940 with the function of advising on problems of nutrition in connection with national defense. Immediately the need was recognized for standards on which some degree of general agreement could be expected. It was realized that requirements could not be established definitely on the basis of knowledge available, but it was desired to survey existing evidence and to derive a table of allowances that would represent, so far as possible, the combined judgment of nutrition authorities and thus be widely accepted and used. Standards previously proposed by various individuals and groups dealt almost exclusively with minimum requirements. It seemed preferable to the Board to formulate allowances suitable for maintenance of good nutritional status.

The published evidence concerning the requirements for the various dietary essentials was critically examined and appraised. In addition, a large number of nutrition authorities, particularly those engaged actively in research, were asked for their judgments as to the requirements for any factors for which they had experimental or other basis for a decision. Tentative allowances were formulated from the evidence thus assembled. These suggested allowances were submitted to all contributors, as well as to all members of the Board, for criticism. The allowances were reformulated on the basis of the replies, resubmitted and again revised. The values thus derived were adopted by the Board in May 1941, and were published as National Research Council Reprint and Circular Series No. 115, January 1943.<sup>1</sup> The values represented the combined judgment of more than fifty persons qualified to express an opinion. It is not to be implied that every contributor agreed fully with all the values adopted, but the contributors and the Board were willing to accept the values tentatively until standards derived from more extensive and exact research data could be obtained. The term "Recommended Allowances" rather than "Standards" was adopted by the Board to avoid any implication of finality.

In 1942 the Allowances were extended by the addition of recommendations concerning iodine, copper, and vitamin K, but without change in any preceding recommendation.

In June 1944, when increasing evidence indicated that revision of the recommendations for the B group of vitamins had become desirable, a group of persons engaged actively in research in this field in the United States and Canada was brought together. This group reviewed the published evidence and exchanged personal views based on experimental data. Because more evidence existed for thiamine than for other B factors, the major discussion concerned this factor. Though diversity of opinion developed, the divergence was within a range small enough that compromise values formulated by the committee were acceptable to most of the consultants, including several with extreme views. Similarly, the values were acceptable to the majority of the members of the Food and Nutrition Board. After mature consideration at several meetings of the Board, the revisions included in the present table were adopted in June 1945.

#### BASIS OF ACCEPTANCE OF THE VALUES \*

That which follows is offered in explanation of the original table of allowances and of the recent revision. More recent data concerning requirements for the various essential nutrients will be included in a review in preparation under the auspices of the Board.

*Calories.* The allowances for adults are those commonly accepted for the man and woman of 70 and 56 kg., respectively. The values for children are based on a compilation of the studies in the literature<sup>2</sup> of the values of food consumed and on a preliminary analysis of unpublished studies by Roberts and Blair of several hundred children. The original value of 2800 calories for girls 13 to 15 years of age was reduced to 2600 calories in the 1945 revision. At all age levels the allowance should vary in relation to size and activity. The greatest variation occurs in adolescence. A large, active boy of 15 years may need as much as 5000 calories. In most instances appetite may be depended on for satisfaction of the need when food is available. A deficit is reflected in loss of weight or, in the case of children, by failure to make the normal gain. Even when calorie allowances are used for planning for specific groups, they can be only rough guides.

*Protein.* The protein allowances for adults are based on the standard of one gram for each kilogram of body weight advocated by Sherman.<sup>3</sup> This value has been widely accepted and used as a standard that provides a reasonable margin of safety. The allowances for pregnancy and lactation are based on the observations of Macy and her coworkers,<sup>4</sup> Coons,<sup>5</sup> and others. These investigators showed that growth of the fetus and adnexa in pregnancy and the demands for milk production in lactation greatly increase the protein needs over those of the non-pregnant state. The in-

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\* Much of the material in this section was presented by the Chairman of the Committee on Dietary Allowances in an article published in the *New York State Journal of Medicine*, 44: 59, 1944. It is used here by permission of the author and the publisher.

creased need begins in the latter half of pregnancy and is greatest when lactation has reached its maximum. The values in the table represent relative needs rather than accurate requirements, for the requirement varies with size.

The allowances for children were derived from a compilation of balance studies of children of all ages, as found in the literature. These data indicate that protein intakes for each kilogram with which appropriate positive balances are obtained decrease from 4 to 3.5 gm. in infancy, 3 to 2.5 in early childhood, 2 to 1.5 in late childhood and adolescence, to the adult maintenance standard of 1 gm. The amounts in the table represent approximately these values. The amounts actually required vary with the size of the child and with the quality of the protein. An infant fed human milk thrives with an intake much lower than the recommended allowances.

The allowances recommended are intended to be above minimum requirements; they represent amounts which are desirable in the diet. These amounts can be attained easily in dietaries which provide adequate amounts of other nutrients. In good dietary practice it is safe to supply high quality proteins (animal sources) to the extent of one-third to one-half the total for children; somewhat less will suffice for adults.

*Calcium.* The calcium allowance for adults was based largely on the observations of Steggarda and Mitchell<sup>6</sup> and of Outhouse and coworkers.<sup>7</sup> These investigators found that 11 of 16 subjects were in calcium equilibrium with 10 mg. or less for each kilogram; the remaining 5 required somewhat more. Using the 10 mg. value, the total for a 70 kg. man would be 0.7 gm. It is believed that the allowance should provide some margin over this amount to supply the requirements of the few subjects whose needs are not satisfied by it. The allowance therefore was set at 0.8 gm. for the 70 kg. man. This value approximates closely the one which may be calculated from the data of Leitch.<sup>8</sup>

The allowance recommended for women is the same as that for men, despite their smaller average size, in order to insure ample stores in preparation for maternity. The higher allowances for pregnancy and lactation are intended to provide for the growth of the fetus and for milk production. These increased needs are indicated by the observations of Macy and coworkers, Coons, and others.<sup>9</sup> The precise values given may not be accurate, but they are correct in indicating the need for greatly increased intake of calcium during these periods.

Although numerous calcium balance studies have been carried out with children, only a few have been made from the standpoint of determining the requirement at the time the dietary allowances were formulated; many of these dealt largely with the preschool age, the period of slowest skeletal growth in all childhood. In arriving at the calcium allowances, special consideration was given to the studies by Daniels<sup>10</sup> and by Outhouse<sup>11</sup> of preschool children, and by Wang<sup>12</sup> of adolescent girls. The earlier studies by Sherman and Hawley<sup>13</sup> and by Wang and coworkers<sup>14</sup> were also evaluated, as were the calculations made by Leitch<sup>8</sup> as to the probable requirements during the period of growth. In a study of 10 preschool children Outhouse found as good retention with an intake of 615

mg. as with a larger amount. This result is in accord with those of Daniels and of Wang and with Sherman's early findings in a study of two preschool children. This amount appears sufficient provided the stores are saturated and the diet is otherwise adequate. Because of the relatively small number of children and the short duration of the studies, a margin of safety seemed desirable and an allowance of 1 gm. was recommended.

Beyond the preschool period, data on which to base requirements were meager. The allowances were largely derived from the calculations of Leitch, from balance studies of Wang for adolescent girls, and from Sherman's study of one 12-year-old girl. These studies and calculations indicate that the calcium needs increase through the growth period to well above the 1 gm. level and then decline to that of the adult. With three points established in the manner described—the preschool child, the adolescent girl, and the adult—the values for other ages were interpolated to correspond to the curve of normal growth.

Since the allowances were first proposed, Macy<sup>15</sup> has reported results of long-time balance studies of 21 children 5 to 12 years of age. With intakes closely approximating the dietary allowances, these children had good calcium retentions. The results of this comprehensive study thus support the recommended allowances for children.

*Phosphorus.* In the original table no allowances were formulated for phosphorus, largely because of the view that dietary deficiencies of phosphorus are uncommon and that diets which are adequate in other respects, particularly in calcium, are ordinarily adequate in phosphorus. For the purpose of making the 1945 revision, a large amount of published and unpublished data from balance studies was brought together and the data evaluated. The footnote which has been added to the table of allowances expresses the result with sufficient accuracy so that a separate column in the table does not seem indicated. The suggested values represent amounts of phosphorus in the diets in the various categories when the retention of both calcium and phosphorus was good and when vitamin D was ingested during the period of growth. The suggestions are appropriate only when phosphorus is obtained from diets which may be considered customary or average for this country. When the calories are obtained largely from cereal, computation of the total phosphorus intake may be misleading because phytin phosphorus is utilized poorly unless the supply of vitamin D is adequate. The requirement for phosphorus cannot be considered alone, but must be related to the intake of calcium and protein. Furthermore, the absorption of phosphorus, like that of calcium, varies with the amount of vitamin D.

*Iron.* The recommended allowances for iron were based to a large extent on the conclusion of Sherman<sup>16</sup> that 12 mg. is a desirable level of intake for adults. The mean intake of 8 mg. required by his subjects for equilibrium was increased by 50 percent to attain a standard allowing a margin of safety. There is considerable evidence, especially the observations of McCance and Widdowson,<sup>17</sup> of Hahn,<sup>18</sup> and of others, that adult males can be maintained for short periods of time with very low intakes of iron. However, the 12 mg. level has been retained for the following

reasons: iron deficiencies have been reported in certain population groups; a generous intake may be desirable for other reasons; this level can be attained with little difficulty through the use of otherwise satisfactory diets. Experiments have indicated that iron is absorbed largely in response to a need, as in growth or after loss of blood.

Leverton<sup>19</sup> showed that young women were in equilibrium with an intake of approximately 7 mg. daily. In a later study<sup>20</sup> she found a larger amount to be needed unless the diet contains all other dietary essentials abundantly. When these amounts are increased by 50 percent to give a margin of safety, the recommended allowance of 12 mg. for women becomes justified, for iron like calcium is poorly utilized by many persons.

The demands of pregnancy have been estimated<sup>21</sup> to require an increase of about 3 mg. over the normal requirement. Therefore this amount was added to the 12 mg. allowance assigned to the non-pregnant woman. McCance and Widdowson found good hemoglobin levels in pregnant women with this intake. Although no evidence exists that the need for iron is increased in lactation, since milk contains little, it seemed wise to err on the side of generosity and to retain the same allowance during lactation as for pregnancy.

Studies of the iron requirement for children have been reported only for infancy and the preschool years. Stearns and Stinger<sup>22</sup> and Oldham, Schlutz, and Morse<sup>23</sup> showed that for infants 0.5 mg. for each kilogram is close to the minimum needed to maintain a positive balance and a good hemoglobin level. From a critical appraisal of the results of Rose,<sup>24</sup> Leichsenring and Flor,<sup>25</sup> Ascham,<sup>26</sup> Daniels,<sup>27</sup> and Porter<sup>28</sup> in studies of preschool children it was concluded that the need can be met by 0.3 to 0.4 mg. for each kilogram. The allowances for the preschool years were obtained by using these values in relation to the weights at the different ages. For the child of early school age, 7 to 11 years, the allowances recommended are supported by the observations of Johnston,<sup>29</sup> who found that children of these ages could maintain normal hemoglobin levels with an intake of 0.35 mg. for each kilogram, or a daily total of 9 to 10 mg.; larger amounts caused no improvement. No data are available for the requirement during adolescence. The allowances recommended were estimated on the assumption that needs are greater than those of the adult.

*Vitamin A.* Greater divergence of judgment exists as to the requirement for vitamin A than for any other dietary essential. Three factors contribute to this situation, namely: no method for determining the requirement is generally accepted; the amount needed varies with the source, whether it is the vitamin itself or its precursor carotene; the capacity of the body for storage is a complicating factor. Most of the estimations of the human requirement in the literature are based on studies of the amount needed to maintain normal dark adaptation of the eye.

The allowance of 5,000 I.U. for adults was based largely on the studies of Booher,<sup>30</sup> Blanchard,<sup>31</sup> and Guilbert<sup>32</sup> and on the critical evaluation of the literature by With.<sup>33</sup> These studies indicated that the requirement is 25 to 55 units for each kilogram, or 2,000 to 4,000 units daily for the adult, and twice these amounts or more if the source is carotene. Because approxi-



mately two-thirds of the vitamin A value of the average diet in this country is contributed by carotene, it was decided that 5,000 units would represent a fair overall allowance. The allowances for pregnancy and lactation were arbitrarily increased over those for other adults by amounts estimated to meet the added needs.

Because few studies indicating requirements have been made with children, the allowances were formulated on the basis of the judgment of the referees and on calculations based on weight. It is generally agreed that the vitamin A requirement is related to body weight rather than to energy expenditure. If the requirements for children are computed according to weight on the basis of Booher's highest estimate of the need of the adult, the values for boys, for example, would be 550 units at one year; 1,000 at 4; 1,430 at 8; 2,200 at 12; and 3,300 at 16 years. If we assume that the requirements are relatively higher on the basis of weight, as in the case of protein and the minerals, and multiply these values by appropriate factors (for example, those from protein, as 3, 2.5, 2, 1.5) values approximating the recommended allowances are obtained. Amounts in excess of the accepted values are easily obtained in diets containing desirable amounts of milk, eggs, and green vegetables.

*Thiamine.* The thiamine allowances of the original table were based to a considerable extent on the observations of Williams, Mason, Wilder, and Smith<sup>34</sup> with induced thiamine deficiency and with step-wise increase in thiamine intake. With depleting diets, the urinary excretions of thiamine became very small and objective symptoms developed. With graded doses of thiamine, excretions increased and symptoms disappeared when the intake approached 1 mg. With an increase to 2 mg., improvement continued to an optimum state and urinary excretion of thiamine increased greatly. One milligram appeared to represent something less than the minimum requirement of these subjects, whereas 2 mg. was more than adequate. Considering 1.25 mg. as a safe daily allowance, the allowance for each 1,000 calories became 0.5 mg. This value corresponds fairly well with the observations of Melnick and Field,<sup>35</sup> who found that 1 mg. was sufficient to maintain good excretion levels in adults; of Wang and Yudkin,<sup>36</sup> who found good excretions with an intake of 1.35 mg.; and with the estimate of Hughes,<sup>37</sup> from his studies of pigs, that an average man of 70 kg. would require 1.5 mg., or 0.5 mg. for each 1,000 calories.

In the original table the thiamine allowances for the several categories were based on the concept that a definite ratio exists between calories and thiamine throughout the entire calorie range. In the conference of consultants in preparation for the 1945 revision it was agreed that the proportion of thiamine required decreases as the calories increase above the lower levels. Despite the change of ratio with calorie level, the custom of relating the thiamine requirement to calories still seems most suitable for practical usage. Acceptance of the concept of decreased proportion of thiamine requirement at the higher calorie levels is responsible for the greatest change made in the thiamine allowances for the present revision.

At the conference of consultants both published and unpublished evidence was considered. Much of the published evidence is cited in the

preceding discussion. At the conference and subsequently it was generally, but not unanimously, agreed that approximately 0.5 mg. for each 1,000 calories is a reasonable and safe allowance for adults at ordinary low levels of calorie intake. Thus was derived the value of 1.5 mg. for a man receiving 3,000 calories. For very active persons for whom the energy requirement exceeds 3,000 calories, the thiamine allowance should be increased 0.3 mg. for each additional 1,000 calories.

The chief evidence as to the needs of children was supplied by Schlutz and Knott.<sup>38</sup> For normal excretion, infants required from 240 to 420  $\mu$ gm. daily. The need at the preschool age was found to be approximately 900  $\mu$ gm. Robb, Valteich, and Rose<sup>39</sup> found that the intake of apparently healthy preschool children ranged from 564 to 910  $\mu$ gm. Computation of the results of these three studies on the basis of calories gives a standard approximating 0.5 mg. for each 1,000 calories. Because this value applies to infants, to preschool children, and to adults with moderate calorie intake, it was assumed that it applies also to other ages in childhood.

*Riboflavin.* At the time of formulating the original table of allowances, the results of only two experiments were available for determining the riboflavin requirement, one by Sebrell and Butler<sup>40</sup> and the other by Strong, Feeney, Moore, and Parsons.<sup>41</sup> In both studies it was found that with an intake of 2 mg., the excretion did not equal that obtained from the control diet, but with an intake of 5 mg., urinary excretion increased sharply. From these results a requirement of 3 mg. was deduced. In appraising the data the committee concluded that somewhat less than this amount might be satisfactory. Another consideration was the relationship which had been shown in experimental animals between the thiamine and the riboflavin requirements, a ratio of 2 to 3. Adding 50 percent to the original thiamine allowance of 1.8 mg. for the moderately active man receiving 3,000 calories gave a riboflavin allowance of 2.7 mg., the value recommended.

Newer evidence indicates that the former riboflavin allowances were unnecessarily generous, especially at the levels of higher calorie intake. Several groups of workers<sup>42</sup> have shown that intakes of 0.31 to 0.35 mg. for each 1,000 calories for periods of several months did not result in evidence of deficiency other than reduced urinary excretion. Williams and coworkers found that 0.5 mg. approximated the minimum at which excretions indicated fairly satisfactory stores and that 0.8 mg. is probably in excess of the need. Several workers have shown that 0.6 mg. for each 1,000 calories is adequate for maintaining good body stores as indicated by urinary excretions. The newly recommended allowances represent reductions of the earlier ones for adults and older boys, but not for pregnancy and lactation, for which it was believed desirable to maintain high standards. The new recommendations for riboflavin were influenced also by the finding with growing animals that the riboflavin requirement is related to the thiamine requirement in the approximate proportion of three to two. Because the requirement for thiamine rests on somewhat firmer ground than that for riboflavin, the recommended riboflavin allowance has been kept roughly proportionate to that recommended for thiamine. Furthermore,

RECOMMENDED DIETARY ALLOWANCES, REVISED 1945<sup>1</sup>  
(AMOUNTS PER DAY)

Food and Nutrition Board, National Research Council

	Calories	Protein grams	Calcium grams	Iron mg.	Vitamin A I. U. <sup>2</sup>	Thiamine mg. <sup>3</sup>	Riboflavin mg. <sup>3</sup>	Niacin (Nicotinic acid) mg. <sup>3</sup>	Ascorbic acid mg.	Vitamin D I. U.
<b>Man (154 lb., 70 kg.)</b>										
Sedentary.....	2500	70	0.8	12 <sup>4</sup>	5000	1.2	1.6	12	75	5
Moderately active.....	3000	70	0.8	12 <sup>4</sup>	5000	1.5	2.0	15	75	5
Very active.....	4500	70	0.8	12 <sup>4</sup>	5000	2.0	2.6	20	75	5
<b>Woman (123 lb., 56 kg.)</b>										
Sedentary.....	2100	60	0.8	12	5000	1.1	1.5	11	70	5
Moderately active.....	2500	60	0.8	12	5000	1.2	1.6	12	70	5
Very active.....	3000	60	0.8	12	5000	1.5	2.0	15	70	5
<b>Pregnancy (latter half).....</b>	2500 <sup>6</sup>	85	1.5	15	6000	1.8	2.5	18	100	400 to 800
<b>Lactation.....</b>	3000	100	2.0	15	8000	2.0	3.0	20	150	400 to 800
<b>Children up to 12 yrs.<sup>7</sup>:</b>										
Under 1 yr. <sup>8</sup> .....	100/2.2 lb. (1 kg.)	3.5/2.2 lb. (1 kg.)	1.0	6	1500	0.4	0.6	4	30	400 to 800
1-3 yrs. (29 lb., 13 kg.).....	1200	40	1.0	7	2000	0.6	0.9	6	35	400
4-6 yrs. (42 lb., 19 kg.).....	1600	50	1.0	8	2500	0.8	1.2	8	50	400
7-9 yrs. (55 lb., 25 kg.).....	2000	60	1.0	10	3500	1.0	1.5	10	60	400
10-12 yrs. (75 lb., 34 kg.).....	2500	70	1.2	12	4500	1.2	1.8	12	75	400
<b>Children over 12 yrs.<sup>7</sup>:</b>										
Girls, 13-15 yrs. (108 lb., 49 kg.).....	2600	80	1.3	15	5000	1.3	2.0	13	80	400
16-20 yrs. (119 lb., 54 kg.).....	2400	75	1.0	15	5000	1.2	1.8	12	80	400
Boys, 13-15 yrs. (103 lb., 47 kg.).....	3200	85	1.4	15	5000	1.5	2.0	15	90	400
16-20 yrs. (141 lb., 64 kg.).....	3800	100	1.4	15	6000	1.8	2.5	18	100	400

[or.]

<sup>1</sup> Tentative goal toward which to aim in planning practical dietaries; can be met by a good diet with a variety of natural foods. Such a diet will also provide other minerals and vitamins, the requirements for which are less well known.

<sup>2</sup> The allowance depends on the relative amounts of vitamin A and carotene. The allowances of the table are based on the premise that approximately two-thirds of the vitamin A value of the average diet in this country is contributed by carotene and that carotene has half or less than half the value of vitamin A.

<sup>3</sup> For adults (except pregnant and lactating women) receiving diets

supplying 2,000 calories or less, such as reducing diets, the allowances of thiamine, riboflavin, and niacin may be 1 mg., 1.5 mg., and 10 mg. respectively. The fact that figures are given for different calorie levels for thiamine, riboflavin, and niacin does not imply that we can estimate the requirement of these factors within 500 calories, but they are added merely for simplicity of calculation. Other members of the B complex also are required, though no values can be given. Foods supplying adequate thiamine, riboflavin, and niacin will tend to supply sufficient of the remaining B vitamins.

<sup>4</sup> There is evidence that the male adult needs little or no iron.

The allowance will be provided if the diet is satisfactory in other respects.

<sup>5</sup> For persons who have no opportunity for exposure to clear sunshine and for elderly persons, the ingestion of small amounts of vitamin D may be desirable. Other adults probably have little need for vitamin D.

<sup>6</sup> During the latter part of pregnancy the allowance should increase approximately 20 percent over the preceding level. The value of 2500 calories represents the allowance for pregnant, sedentary women.

<sup>7</sup> Allowances for children are based on the needs for the middle year in each group (as 2, 5, 8, etc.) and are for moderate activity and for average weight at the middle year of the age group.

<sup>8</sup> Needs of infants increase from month to month with size and activity. The amounts given are for approximately 6 to 8 months. The dietary requirements for some of the nutrients such as protein and calcium are less if derived largely from human milk.

#### *Further recommendations:*

**Fat.** There is available little information concerning the human requirement for fat. Fat allowances must be based at present more on food habits than on physiological requirements. While a requirement for certain unsaturated fatty acids (the linoleic and arachidonic acids of natural fats) has been amply demonstrated with experimental animals, the human need for these fatty acids is not known. In spite of the paucity of information on this subject there are several factors which make it desirable that fat be included in the diet to the extent of at least 20 to 25 percent of the total calories and that the fat intake include "essential" unsaturated fatty acids to the extent of at least 1 percent of the total calories. At higher levels of caloric expenditure, e.g., for a very active person consuming 4500 calories and for children and adolescent persons, it is desirable that 30 to 35 percent of the total calories be derived from fat. Since foodstuffs such as meat, milk, cheese, and nuts may be expected to contribute "invisible" fat to the extent of from one-half to two-thirds of the total amounts of fat implied by the above proportions of the total calories, it is satisfactory to use separated or "visible" fats such as butter, margarine, lard, and shortenings only to the extent of one-third to one-half of the amounts indicated.

**Copper.** The requirement for copper for adults is about 1 to 2 mg. daily. Infants and children require approximately 0.05 mg. for each kilogram of body weight. The requirement for copper is approximately one-tenth that for iron. A good diet normally will supply sufficient copper.

**Iodine.** The requirement for iodine is small, probably about 0.002 to 0.004 mg. daily for each kilogram of body weight, or a total of 0.15 to 0.30 mg. daily for the adult. This need is met by the regular use of iodized salt; its use is especially important in *adolescence* and *pregnancy*.

**Phosphorus.** Available evidence indicates that the phosphorus allowances should be at least equal to those for calcium in the diets of children and of women during the latter part of pregnancy and during lactation. In the case of other adults the phosphorus allowances should be approximately 1.5 times those for calcium. In general it is safe to assume that if the calcium and protein needs are met through common foods, the phosphorus requirement also will be covered, because the common foods richest in calcium and protein are also the best sources of phosphorus.

**Vitamin K.** The requirement for vitamin K usually is satisfied by any good diet. Special consideration needs to be given to newborn infants. Physicians commonly give vitamin K either to the mother before delivery or to the infant immediately after birth.

**Salt.** The needs for salt and for water are closely interrelated. A liberal allowance of sodium chloride for the adult is 5 grams daily, except for some persons who sweat profusely. The average normal intake of salt is 10 to 15 grams daily, an amount which meets the salt requirements for a water intake up to 4 liters daily. When sweating is excessive, one additional gram of salt should be consumed for each liter of water in excess of 4 liters daily. With heavy work or in hot climates 20 to 30 grams daily may be consumed with meals and in drinking water. Even then, most persons do not need more salt than usually occurs in prepared foods. It has been shown that after acclimatization persons produce sweat that contains only about 0.5 gram to the liter in contrast with a content of 2 to 3 grams for sweat of the unacclimatized person. Consequently after acclimatization, need for increase of salt beyond that of ordinary food disappears.

**Water.** A suitable allowance of water for adults is 2.5 liters daily in most instances. An ordinary standard for diverse persons is one milliliter for each calorie of food. Most of this quantity is contained in prepared foods. At work or in hot weather, requirements may reach 5 to 13 liters daily. Water should be allowed *ad libitum*, since sensations of thirst usually serve as adequate guides to intake except for infants and sick persons.

evidence from experiments of Sherman and associates with animals suggested that short-term observations are particularly unreliable in judging requirements for riboflavin. Therefore it seems desirable, until evidence from longer periods of controlled observations on man has been presented, to strive for liberal allowances of this vitamin.

*Nicotinic acid (Niacin).* At the time of formulating the original table of allowances no human experiments on which to base a requirement were on record. The recommended values were based largely on calculations from the requirement of dogs as found by Elvehjem and on the checking of these calculated values against diets known to be adequate for prevention of pellagra. When the allowances were thus calculated for the different ages, it was found that they were approximately ten times the thiamine allowances. This observation gave support to the computed values in that the requirement of these two materials might be expected to bear a constant relationship to each other because they, together with riboflavin, play a part in the oxidation-reduction systems of the body, through which the energy of foods is released. At the time of the 1945 revision, evidence as to niacin requirement still remained less adequate than for many of the other factors. Decision was made to retain the ten-to-one relationship with thiamine, a procedure which decreases the recommended allowances at levels of higher calorie intakes. It should be pointed out that the niacin intakes of children may be adequate even when less than the recommended allowance, provided the diets contain appropriate quantities of milk.

*Ascorbic acid.* More complete evidence exists concerning the requirements for ascorbic acid for different age groups and conditions than for any of the other vitamins. Methods for determining the needs are better developed and accepted and more studies have been made. Among the studies used in deriving the allowances were those of O'Hara and Hauck,<sup>43</sup> Todhunter and Robbins,<sup>44</sup> and Fincke and Landquist<sup>45</sup> for adults; Roberts and Roberts<sup>46</sup> for children of 8 to 12 years; Hathaway and Meyer<sup>47</sup> for preschool years; Selleg and King<sup>48</sup> for infants. In these and other studies, both the blood level of ascorbic acid and the urinary excretion test have been used as evidence of adequate stores and an attempt was made to find the lowest level of intake that will maintain adequate stores as judged by these criteria. The chief points of controversy have been: What constitutes a normal blood level and what urinary excretion response to a test dose indicates adequate stores?

On the basis of the evidence mentioned, allowances were formulated for the different ages and categories, submitted to consultants for criticism, and revised. In addition, a group composed of consultants who have done extensive work in this field was brought together for further consideration of the revised allowances. The values thus derived represent amounts well above the minimum needed to protect against scurvy, but below those needed for saturation.

*Vitamin D.* The vitamin D requirement has been studied more extensively for infancy than for any other age period. Despite this fact, some controversy exists, chiefly because of differences in the criteria used. The range of 400 to 800 units daily for infants as stated in the table represents

a compromise among the consultants. Evidence exists<sup>49</sup> that from 300 to 400 units daily commonly permits maximum calcium retention in infancy when the calcium intake is satisfactory. Maximum calcium retention is associated with excellent skeletal growth and early dentition.<sup>50</sup> Larger amounts of vitamin D do not increase calcium retention or the rates of growth and dentition.<sup>51</sup> Nevertheless, a number of consultants found a somewhat larger amount more acceptable as a suitable allowance.

Evidence is good that vitamin D is required throughout the growth period, but the actual requirement has not been accurately determined. It is known, however, that 400 units daily is ample for good calcium retention in children when the milk intake is appropriate. A few children do not require a supplement of vitamin D for good calcium retention, but the majority do. In adolescence, however, recent unpublished evidence indicates that the need for vitamin D is as universal and as great as in infancy. The total amount required in adolescence probably is no greater than in infancy.

The need for supplemental vitamin D by vigorous adults leading a normal life seems to be minimum. For persons working at night and for elderly persons, the ingestion of small amounts of vitamin D may be desirable. When adults are receiving only small amounts of calcium, ingestion of vitamin D does not increase the utilization of that which is ingested, nor does vitamin D decrease the requirement for calcium.<sup>52</sup>

During pregnancy and lactation the calcium and phosphorus requirements are greatly increased. Supplemental vitamin D increases the utilization of these materials. The optimum amount of vitamin D is not known, but retention values obtained by some investigators with high dosages of vitamin D seem no greater than those with moderate dosage. It was agreed by the consultants, on the basis of available evidence, that the values of the table probably are adequate.

#### GENERAL DISCUSSION \*

From the preceding discussion it is obvious that experimental evidence for human requirements is far from adequate, especially for vitamin A and the B group of vitamins. Even though the requirement is fairly well established for a number of essentials for certain age groups or conditions, rarely is information available from a complete series of studies, especially throughout the growth period. Data concerning the period of adolescence are conspicuously lacking. Thus it became necessary to formulate many of the allowances in part on the basis of the judgment of nutrition workers whose experiences permitted decisions as to the values to interpolate for those that were lacking. Undoubtedly, continued research will make further revision of the allowances necessary.

The allowances for adults are given for a man of 70 kg. and a woman of 56 kg. They should be decreased or increased proportionately for smaller or larger persons and for different levels of activity. The allow-

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\* Some of the material of this section was presented by the Vice-Chairman of the Committee on Dietary Allowances in an article published in *Science*, 101:285, 1945. It is used here by permission of the author and the publisher.

ances for children are given for age groups, and for boys and girls separately after 12 years because from that age the growth curves and levels of activity differ. The values stated are for the middle age of the group and for children of average size and activity.

The allowances during the growth period as shown in the table may appear to have step-like changes from one age category to another because of their being tabulated by age groups. Obviously such abrupt changes in requirement cannot occur. A man lacking one day of being 21 years of age does not have a protein requirement which decreases overnight from 100 to 70 grams. Actually the allowances are stated for the middle of the age group and they are different on each side of the middle. When the allowances that are given are plotted by age, a curve is obtained that permits interpolation for ages for which no values are given. The curve of values slopes gradually from those stated for 18 years to those for adults, beginning at 21 years. For most of the nutrients listed the values at 20 years are little different from those at 21. Since size is as important as age, if not more important, at different periods of development, probably a band rather than a line on a graph represents the truth more adequately.

The allowances are for persons in health. Needs vary greatly in disease. For example, in febrile conditions an increased need usually exists for calories, thiamine, and ascorbic acid. The need for these and other constituents may be greatly altered also in other diseases, especially those of the alimentary tract which interfere with absorption.

The values of the table are for content of foods as eaten and do not allow for losses in storage, cooking, and serving. Because such losses, especially of the water-soluble vitamins, may be extensive, provision should be made for them in planning practical dietaries.

The allowances are intended to serve as a guide for planning an adequate diet for every normal person of the population and not for the average member of the group categories. Experience has shown that the biological normal consists of a range of values. An allowance based on the need of the average of a group would be greater than the need of many and less than the need of many others. Many normal adult males require only 2,200 calories or less and many can subsist in health with half the stated protein allowance. Many children need no supplemental vitamin D, while others require the amount stated. In order to meet the needs of the whole population it is necessary to satisfy the requirements of those with less efficient usage. Because the allowances take into consideration the requirements of those at the upper level of the normal range of requirement, they allow a factor of safety for persons who have an average or less than average requirement. In most categories this factor of safety is approximately 30 percent, but for many normal persons the allowances cover only the amounts needed for maintenance. Inasmuch as many persons who receive less than the recommended allowance of one or another nutrient may remain in excellent health through long periods, it becomes apparent that these allowances are not to be used as the sole criterion for judging the state of nutrition of any population.

In addition to meeting the immediate needs of normal persons with relatively low efficiency, the allowances are expected to cover for the average person any differences that might exist between short-time need and that for the life span, though information is lacking that would permit stating with accuracy the amounts of the various nutrients more suitable for the whole life span. The various studies that have been used as a basis for judgment as to minimum requirements were for periods not longer than 6 to 9 months, not more than 1 percent of the life span. Studies with animals have indicated that amounts of some nutrients sufficient to provide health for short portions of the life span may be inadequate to maintain good health for the life span as a whole.

When the tables are used to estimate the per capita needs of population groups and the agricultural production required to supply such groups, the allowances should be weighted by the composition of the population according to the categories and ages. When the allowances are weighted in this manner, the average allowance for each individual is lower than that for a man for all factors except calcium. The amount by which it is less varies from 7 to 16 percent according to the factor calculated. Even when weighted in this manner, the allowances are greater than the average or the mode of the need for many factors because the allowances are planned to be sufficiently high to meet the needs of normal persons who are less efficient in utilization.

While the allowances do not provide a basis for judging nutritional status of populations, they nevertheless serve as a guide for feeding population groups. It seems preferable to present as a goal the nutritional welfare of the majority of persons, without limitation to those with average requirement or less. Few persons know whether their individual needs are greater or less than the average and no easy method exists for determining such status. If the total food supply for a population is insufficient to meet these recommendations, the remaining existing need must be recognized frankly despite the embarrassment that may ensue. It becomes necessary to distinguish between standards based on good nutrition for all and more immediate consumption goals based on practical possibilities.

#### DIET PLANS THAT MEET THE RECOMMENDED DIETARY ALLOWANCES

In using the recommended allowances it is to be emphasized that the amounts of the various nutrients, with the exception of vitamin D, can be obtained through a good diet of natural foods. Flour should be whole grain or enriched. Excessive use of vitamin-poor foods should be avoided and loss and waste in preparation and serving should be minimized.

It is fortunate that optimum nutrition can be provided by an unlimited number of combinations of foods. It is expected that nutrition workers will translate the allowances into appropriate quantities of foodstuffs available in their own localities and suited to the income level of the group concerned. The allowances, expressed in terms of everyday local foods, can be used widely in nutrition work.

The safest way to insure that the allowances are met is to include cer-



tain foods in the diet (daily) in specified amounts. One dietary pattern which contains a variety of foods commonly available is given below.

*List 1*

- Milk .....1 pint daily
- Egg .....1 daily if possible. On days when not used, beans, peanuts, cheese, or more milk or meat should be used instead.
- Meat, fish, or fowl.....1 or more servings
- Potato .....1 or more
- Vegetables .....2 or more servings
- Fruits .....2 or more. One citrus fruit or tomato or other good source of vitamin C.
- Cereals and bread.....Whole grain or enriched.
- Other foods as needed to complete the meal.

List 1 is based on the needs of an adult. A serving of a vegetable or fruit is assumed to be at least one cup or 4 ounces or its equivalent. For children the milk should be increased, but the kinds of foods to be included remain the same, the amounts of the portions varying with the sizes of the children.

Another list using less milk and lean meat is given as illustrative of the varied ways in which the allowances may be met.

*List 2*

- Turnip greens .....1 cup
- Sweet potatoes .....3
- Peanuts .....20 nuts or 2 tablespoons peanut butter
- Beans or cow peas.....1½ ounce
- Tomatoes .....1 cup
- Corn meal .....3 ounces
- Enriched flour .....3 to 4 ounces
- Milk (fresh, evaporated, or dried) .....One-third quart
- Lean pork .....Small serving 3 to 4 times a week
- Molasses, fat, etc., to complete the meals.

These lists meet the dietary allowances. Numerous other combinations could be planned which are equally adequate, and adapted to the available food supplies and dietary customs in a given situation. It should be remembered, however, that, once these combinations are derived, each food in such a list plays a specific role and if omitted should be replaced by another of equal food value.

REFERENCES

1. Recommended Dietary Allowances. National Research Council Reprint and Circular Series No. 115, January 1943.
2. White House Conference, Growth and Development of the Child. New York. Century Co., 1932, Part 3, 396.

3. Sherman, H. C. *Chemistry of Food and Nutrition*. New York. Macmillan Co., 1941, 204.
4. Macy, I. G., Hunscher, H. A., Nims, B. and McCosh, S. S. *J. Biol. Chem.* 86: 17, 1930.  
Shukers, C. K., Macy, I. G., Donelson, E., Nims, B. and Hunscher, H. A. *J. Nutr.* 4: 399, 1931.
5. Coons, C. M. *Studies in Metabolism in Pregnancy*. Oklahoma Agricultural Experiment Station Bulletin, No. 223, 1935.
6. Steggarda, F. R. and Mitchell, H. H. *J. Nutr.* 17: 253, 1939; *J. Nutr.* 21: 577, 1941.
7. Outhouse, J., Breiter, H., Rutherford, E., Dwight, J., Mills, R. and Armstrong, W. J. *J. Nutr.* 21: 565, 1939.
8. Leitch, I. *Nutr. Abstr. and Rev.* 6: 553, 1937.
9. *Loc. cit.* 4 and 5.
10. Daniels, A. L., Hutton, M. K., Knott, E., Everson, G. and Wright, O. *Amer. J. Dis. Child.* 47: 499, 1934.
11. Outhouse, J., Kinsman, G., Sheldon, D., Twomey, I., Smith, J. and Mitchell, H. H. *J. Nutr.* 17: 199, 1939.
12. Wang, C. C., Kaucher, M. and Wing, M. *Amer. J. Dis. Child.* 52: 41, 1936.
13. Sherman, H. C. and Hawley, E. J. *Biol. Chem.* 53: 375, 1922.
14. Wang, C. C., Kern, R. and Kaucher, M. *Amer. J. Dis. Child.* 39: 768, 1930.
15. Macy, I. G. *J. Amer. Dietet. Assn.* 20: 602, 1944.  
*Nutrition and Chemical Growth in Children*. Vol. I. Evaluation. Springfield, Illinois, Charles C. Thomas, 1942.
16. *Loc. cit.* 3, 287.
17. McCance, R. A. and Widdowson, E. M. *Lancet* 2: 680, 1937; *Biochem. J.* 31: 2029, 1937; *J. Physiol.* 94: 148, 1938.
18. Hahn, P. F. *Medicine.* 16: 249, 1937; *J. A. M. A.* 111: 2285, 1938.
19. Leverton, R. M. *J. Nutr.* 21: 617, 1941.
20. Leverton, R. M. and Marsh, A. G. *J. Nutr.* 23: 229, 1942.
21. Coons, C. M. *J. Biol. Chem.* 97: 215, 1932.  
Toverud, K. U. *Acta. Ped.* 17: suppl. 131-135, 1935.
22. Stearns, G. and Stinger, D. *J. Nutr.* 13: 127, 1937.
23. Oldham, H., Schlutz, F. W. and Morse, M. *Amer. J. Dis. Child.* 54: 252, 1937.
24. Rose, M. S., Valteich, E. McC., Robb, E. and Bloomfield, E. M. *J. Nutr.* 3: 299, 1930-31.
25. Leichsenring, J. M. and Flor, I. H. *J. Nutr.* 5: 141, 1932.
26. Ascham, L. *J. Nutr.* 10: 337, 1935.
27. Daniels, A. L. and Wright, O. E. *J. Nutr.* 8: 125, 1934.
28. Porter, T. *J. Nutr.* 21: 101, 1941.
29. Johnston, F. A. and Roberts, L. J. *J. Nutr.* 23: 181, 1942.
30. Booher, L. E., Callison, E. C. and Hewston, E. M. *J. Nutr.* 17: 317, 1939.  
Booher, L. E. and Callison, E. C. *J. Nutr.* 18: 459, 1939.
31. Blanchard, E. L. and Harper, H. A. *Arch. Int. Med.* 61: 661, 1940.
32. Guilbert, H. B., Howell, C. E. and Hart, G. H. *J. Nutr.* 19: 91, 1940.
33. With, Torben K. *Absorption, Metabolism and Storage of Vitamin A and Carotene—with some remarks on the Vitamin A requirement*. Copenhagen, Einar Munksgaard, 1940, p. 263.
34. Williams, R. D., Mason, H. L., Wilder, R. M. and Smith, B. F. *Arch. Int. Med.* 66: 785, 1940; 69: 721, 1942.
35. Melnick, D., Field, H. Jr. and Robinson, W. D. *J. Nutr.* 18: 593, 1939.
36. Wang, Y. L. and Yudkin, R. *Biochem. J.* 24: 343, 1940.
37. Hughes, E. H. *J. Nutr.* 20: 239, 1940.
38. Schlutz, F. W. and Knott, E. M. *Amer. J. Dis. Child.* 61: 231, 1941; *J. Nutr.* 15: 411, 1938.
39. Robb, E., Valteich, E. Mc. and Rose, M. S. *Amer. J. Dis. Child.* 55: 544, 1938.
40. Sebrell, W. H. and Butler, R. E. *U. S. Pub. Health Reports.* 53: 2282, 1938.
41. Strong, F. M., Feeney, R. E., Moore, B. and Parsons, H. T. *J. Biol. Chem.* 137: 363, 1941.
42. Williams, R. D., Mason, H. L., Cusick, P. L. and Wilder, R. M. *J. Nutr.* 25: 361, 1943.

- Keys, A., Henschel, A., Taylor, H. L., Mickelson, O. and Brozek, J. J. *Nutr.* 27: 485, 1944.
- Oldham, H., Johnston, F., Kleiger, S. and Arismendi, H. H. *J. Nutr.* 27: 435, 1944.
43. Belser, W. B., Hauck, H. M., and Storvick, C. A. *J. Nutr.* 17: 513, 1939.
44. Todhunter, E. N. and Robbins, R. C. *J. Nutr.* 19: 263, 1940.
45. Fincke, M. L. and Landquist, V. L. *J. Nutr.* 23: 483, 1942.
46. Roberts, V. M. and Roberts, L. J. *J. Nutr.* 24: 25, 1942.
47. Hathaway, M. L. and Meyer, F. L. *J. Nutr.* 21: 503, 1941.
48. Selleg, I. and King, C. G. *J. Nutr.* 11: 599, 1936.
49. Jeans, P. C. and Stearns, G. *J. A. M. A.* 111: 703, 1938. *Proc. Soc. Exper. Biol. and Med.* 31: 1159, 1934; 32: 1464, 1935; Unpublished data.
50. Stearns, G., Jeans, P. C. and Vandecar, V. *J. Ped.* 9: 1, 1936.
- Speidel, T. D. and Stearns, G. *J. Ped.* 17: 506, 1940.
51. Jeans, P. C. and Stearns, G. *J. Pediat.* 13: 730, 1938.
52. Hart, M. C., Tourelotte, D. and Heyl, F. W. *J. Biol. Chem.* 76: 143, 1928.
- Kelly, F. C. and Henderson, J. M. *J. Hygiene.* 29: 418, 1930.
- Bauer, W., Marble, A. and Clafin, D. *J. Clin. Invest.* 11: 1, 1932.
- Hunscher, H. A., Danielson, E., Erickson, B. N. and Macy, I. G. *J. Nutr.* 8: 341, 1934.
- McKay, H., Patton, M. B., Pittman, M. S., Stearns, G. and Edelblute, N. *J. Nutr.* 26: 153, 1943.

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