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Chapter 4

Agriculture and the Nation's Food

BETWEEN 80 and 90 percent of our agricultural output eventually finds its way into the food basket of the nation. Because the volume as well as the character of agricultural production are intimately related to changes in dietary habits, we have made the demand for food the subject of a separate chapter whose findings will have some bearing upon every group of foodstuffs dealt with in the preceding pages.

THE MEASUREMENT OF FOOD VALUES

The diet of a country [1] at any given moment is determined by many factors. The natural resources, including climate and soil, the state of the industrial arts, transportation and distribution facilities, the composition of the population, progress in the science of nutrition, the course and distribution of real income in the community—all these jointly influence food consumption. But the choices exercised by the consumer in deciding what to eat are not, for the most part, in terms of the nutrients of which food materials are composed. A housewife buys a quart of milk or a loaf of bread; she does not ask for a thousand calories or a milligram of riboflavin. Yet we cannot appraise the food supply in a physi-

[1] In this chapter we are concerned exclusively with changes in food consumption of the population as a whole. Consequently, we must deal in averages. The reader should be aware that the dispersion about this average may be as important as changes within it. The present emphasis is thought important, however, since there is available a large amount of material on differences in food expenditure by income groups, whereas little research has been undertaken on the development of food consumption as a whole.

ological sense, judge its adequacy, or examine the scope for its improvement in the future, unless we talk in terms of food values rather than of foods themselves. Nutrition is a science of comparatively recent growth: but there are signs that it may already have influenced dietary habits, and it can be expected to do so in increasing measure in the future.

The energy-yielding qualities of a food material are measured in calories,[2] which are derived from three broad classes of chemical substances known respectively as proteins, carbohydrates and fats. Besides these three classes of nutrient, which together with water account for the major part of the bulk and weight of most foodstuffs, minute quantities of numerous other substances are necessary to the maintenance of the health of humans and animals alike. So far as is now known, the latter consist of vitamins—complex organic substances—and individual chemical elements such as calcium, phosphorus and iron.

The present extent of our knowledge may be indicated most conveniently by a brief survey of the more important discoveries in the field of nutrition. As a starting point, in order to illustrate the state of the science of nutrition at the turn of the century, we may mention the researches carried on at that time by W. O. Atwater to whom the first systematic description of the energy content of various foods is to be credited,[3] and whose results have been superseded only to a minor extent. Perhaps inevitably Atwater stressed energy content almost to the exclusion of other aspects of foods. His views, which are characteristic of his era, have been summarized as follows:

[2] Throughout the chapter reference is to so-called "large" calories, the unit commonly employed in nutritional analysis. This represents the amount of heat required to raise the temperature of one kilogram of water one degree centigrade; or 4 pounds of water one degree Fahrenheit, approximately.

[3] See *Chemistry and Economy of Food,* Experiment Station Bulletin 21 (U. S. Department of Agriculture, 1895); W. O. Atwater and A. P. Bryant, *The Chemical Composition of American Food Materials,* Experiment Station Bulletin 28 (1896; reprinted 1906).

> He believed that if he knew the chemical composition and the fuel values of all important foods and feeding-stuffs, in terms of their content of protein, carbohydrate, and fats, and the digestibility factors for these, together with the energy requirements of human beings and animals, it would be possible to place nutrition of man and animals on a sound economic basis. He set to work, with the support of the U. S. Department of Agriculture, to analyze all American foods . . . Atwater regarded fruits and water-rich fresh vegetables, eggs, etc., as extravagant food purchases. He saw no reason why one should not remain in health while taking a diet selected from the cheapest dried food products.
>
> Atwater visualized the coming of a time when farmers should be able to consult tables showing the cost of protein and energy in various farm crops, and taking into account digestibility of their food elements, to select the cheapest sources of these nutrients for compounding their rations for feeding animals. Fortunately for his peace of mind he never saw the effects of restricting animals or men to diets which might have been compounded on his advice. It is also very fortunate that housewives did not, so far as we are aware, attempt to follow his advice in the feeding of their families.[4]

At the time Atwater wrote, cornmeal was much the cheapest source of calories: it followed that an economical diet would consist predominantly of this substance.[5]

The need for an adequate supply of calories, and therefore of the basic dietetic constituents (proteins, carbohydrates and fats) is of course still recognized. But the problem of determining the food value of proteins has turned out to be more complicated than was earlier supposed. Besides contributing calorific value, proteins are the principal source of nitrogen compounds needed by the body; in fact they supply, through

[4] E. V. McCollum, Elsa Orent-Keiles, and H. G. Day, *The Newer Knowledge of Nutrition* (5th ed; Macmillan, 1939), pp. 10-11. However, although he neither realized the importance of minerals, nor suspected the existence of vitamins, Atwater continually urged that more research was needed.

[5] Atwater, *Chemistry and Economy of Food*, pp. 139-40.

degradation, products essential to tissue-building in growth and maintenance, to reproduction, lactation and other functions of life. These degradation products belong to a large class of organic compounds known as amino acids, some of which are much more useful than others for tissue-building or other specific purposes. Different proteins yield quite different assortments of amino acids, and therefore vary greatly in food value. Some of the amino acids can be synthesized in the body; but the synthesis of others, and therefore of the proteins containing them, cannot be accomplished within the organism. Obviously the true nutritive value of a protein is related to its content of this latter group, the so-called essential amino acids. The systematic appraisal of protein-contributing foodstuffs along these lines has not yet been possible, though it appears that animal-derived proteins rank above all others.[6] For most purposes this question does not appear to have immediate practical importance, however, for the range of proteins available in most diets, except perhaps under siege conditions, is more than sufficient to secure an adequate distribution of amino acids on digestion.[7] Carbohydrates and fats are important chiefly as a source of energy, and their deficiency is easily recognizable in any given diet; moreover the body tolerates the substitution of one carbohydrate or fat for another, so that neither of these elements in nutrition presents a serious problem under ordinary conditions. Our knowledge of protein, carbohydrate and fat requirements in the diet represents in a sense merely an extension of what was already known half a century ago.

Practical recognition of the importance of vitamins may be said to go back to the use of lemon juice by the British navy in 1804, or even earlier, as a preventive of scurvy.[8] Real

[6] McCollum, Orent-Keiles and Day, *op. cit.*, p. 130.

[7] However, it has been suggested that lack of biologically superior protein may contribute to the beriberi of the Indies and the pellagra of our own southern states.

[8] Henry Borsook, *Vitamins* (Viking, 1941), p. 93. The juice of the Mediterranean lemon, known at that time as "lime" juice, was used; it is an important source of vitamin C.

knowledge concerning their properties and availability dates from much more recent times, however. Although it had been suspected as long ago as 1881 that small quantities of definite but complex substances in the diet were essential to the maintenance of health, the beginning of our systematic knowledge concerning vitamins dates only from about the year 1905. Since then experiments in chemical analysis and in the feeding of animals and human beings have led to the isolation of a number of organic substances, all necessary to health, of which in 1940 no fewer than seven had been synthesized commercially.[9] Vitamins are to be distinguished from other complex organic substances important to health, such as hormones, by the fact that (except for vitamin D) they are not manufactured by, and (except for vitamins A and D) are not stored to any great extent by, the human body itself, but must be regularly supplied from outside; hence their importance in diet.

The vitamins are not closely related to each other in a chemical sense, but they have in common (1) that they are necessary in diet only in relatively minute quantity; and (2) that the lack of any one of them invites sooner or later a more or less pronounced pathological condition which, if it does not become too severe, can be cured by restoration of the vitamin to the diet. It is probable also that some of the vitamins actively assist the assimilation of other foodstuffs, although information on this score is still scanty. In general the absence of a vitamin from the diet is not noticed except as a nutritional deficiency disease appears, and the need for vitamins has therefore been described as "hidden hunger," in contrast to the actual hunger resulting from an insufficiency of calories. For the same reason our data on health tell us little about the occurrence of malnutrition, and deaths due to deficiency diseases do not loom large in our vital statistics. Indeed the condition may easily escape notice, or may be

[9] *Ibid.*, p. 7.

wrongly diagnosed,[10] for ". . . in the present state of our knowledge concerning the diagnosis of malnutrition due to many of the specific nutritional factors a wide borderline zone exists between nutritional inadequacy and diagnosable malnutrition." [11]

Vitamin A, discovered in 1913, is necessary to growth and to effective vision, particularly in a dull light, and it also increases resistance to a wide range of infections. It is peculiar among vitamins in that certain related substances, or "precursors," such as the carotenes, can readily be transformed by the body into the vitamin itself, and are therefore satisfactory substitutes. We may regard foodstuffs containing these precursors as containing vitamin A for all practical purposes, and this treatment is usually adopted in nutrition studies. The chief sources of vitamin A (or its precursors) are liver (especially fish liver oils), butterfat, eggs and leafy green and yellow vegetables. Because of the close association with growth, it has sometimes been suggested that this vitamin is less necessary to adults than to children, but this has not been established.[12]

Vitamin B_1 (thiamin), first isolated in 1926, is usually known as the antineuritic vitamin, because its deficiency leads to beriberi, a disease of the nerves of the feet and legs. Its existence was first discovered by the observation that Asiatic populations fed on polished rice contracted beriberi, but recovered when their diet was changed to unpolished rice. Besides its negative function of preventing beriberi it influences normal metabolism, especially of carbohydrates, and even mild deficiency leads to loss of appetite, debility and inefficiency. Vitamin B_1 is widely distributed among food

[10] Norman Jolliffe, J. S. McLester, and H. C. Sherman, "The Prevalence of Malnutrition," *Journal of the American Medical Association,* Vol. 118 (March 21, 1942), pp. 944-50.

[11] *Ibid.,* p. 948. See also pp. 175-78 below.

[12] H. C. Sherman, *Chemistry of Food and Nutrition* (6th ed; Macmillan, 1941), p. 412.

materials, occurring in lean meat, eggs, wholewheat flour, nuts and to a small extent in milk and some fruits and vegetables. However, it is largely lost when flour is refined or rice is polished, and, being soluble in water and susceptible to heat, may disappear in cooking. Vitamin B_2 (or G, riboflavin) resembles vitamin B_1 in that it is water-soluble, plays an important part in the metabolism of the body, and is found in about the same foodstuffs. It was discovered much later, however, and was not isolated until 1933. Another member of the B group, the pellagra-preventive vitamin (nicotinic acid, or niacin) has been discovered still more recently.

The existence of an antiscorbutic factor had been suspected by the early nutritionists, but it was not definitely identified as vitamin C (ascorbic acid) until 1931. Besides preventing scurvy, this vitamin seems to have a general function in cell building. Its availability in food materials is practically confined to fruits and vegetables, and it is found especially in citrus juice. Since vitamin C is water-soluble and easily destroyed by oxidation, losses in processing, storage and cooking are important and probably more serious than in the case of other nutrients. Consequently we have not been able to make estimates for its consumption by the methods followed generally in this chapter.

The antirachitic vitamin D, which is fat-soluble and appears in numerous forms, involves an extremely complicated chemical problem that has not yet been fully solved. Its physiological importance derives from its influence upon calcium metabolism, since its presence is indispensable to bone building. Like vitamin A, it is to be found in liver; it is present also in small quantities in other food materials of animal origin, but is not supplied by vegetables. Data on the vitamin D content of foodstuffs are not at present adequate to permit estimates of its consumption by the methods adopted here. Moreover the problem is complicated by the fact that exposure to sunlight brings about a synthesis of this vitamin within the human body: the degree to which this occurs effectively is related to several factors, among them latitude, smoke in the atmosphere and other conditions. Unfortunately, therefore, estimates of the amount of vitamin D present in foods eaten by a given population may be of little value. The existence of several other vitamins has been established, but too little is known about them to permit one to make estimates of their consumption.

Among individual chemical elements, calcium and phosphorus are important for bone building, and as such are specially needed by growing children. Since both these elements are stored by the body on a much larger scale than any of the vitamins, temporary deficiencies are not so serious, but continuing deficiencies, in children and adults alike, lead to ill health. Calcium and phosphorus are found in milk and eggs, and in smaller quantities in most vegetables.

Iron is a vital constituent of the blood, and as such must be regularly replaced for the maintenance of health. It is found in lean meat, eggs, wholewheat flour, and in many vegetables. An adequate iodine supply is necessary to the proper functioning of the thyroid gland, but we have not been able to measure its consumption here. Apparently numerous other elements also are necessary in minute quantities, although risk of deficiency is slight in most modern diets.[13]

For a more exhaustive discussion of the present state of our knowledge of nutrition the reader is referred to the numerous treatises upon the subject that have appeared in recent years. A complete catalog of the substances necessary for the maintenance of health and efficiency, or even of life itself, cannot yet be compiled. But we do know at least that three broad types of nutrient are indispensable—energy-producing foods (proteins, carbohydrates and fats), vitamins and minerals. How adequate is our food supply, we are naturally

[13] McCollum, Orent-Keiles and Day, *The Newer Knowledge of Nutrition,* Chs. VII-XI; Sherman, *Chemistry of Food and Nutrition,* Chs. XII-XV.

tempted to ask, in terms of these various nutrients? What changes would be called for, in the sphere of agricultural production, by a rise in nutritional standards? In the present chapter we attempt to answer these questions.

THE STATISTICS OF FOOD CONSUMPTION—CALORIES

In principle, if we know the amount consumed of each kind of food, and also its calorie, vitamin or mineral content, we can calculate the average intake of calories (proteins, carbohydrates and fats), vitamins and minerals for the population as a whole. The constitution of common foodstuffs in terms of proteins, carbohydrates and fats is fairly well established. Moreover these energy-producing nutrients account for a major portion of the total weight of most foodstuffs. For these reasons measurement of the per capita intake of calories back to 1899, undertaken in this section, is not a difficult matter. In the case of vitamins and minerals the situation is much more complicated. These nutrients comprise only a minute fraction—and often a highly variable one—of the food materials from which they are supplied. The estimation of per capita consumption of vitamins and minerals is consequently a more formidable undertaking, and the results of the calculations are surrounded by a much larger margin of error than in the case of proteins, carbohydrates and fats. Consequently our estimates for vitamin and mineral consumption (to be presented in subsequent sections of this chapter) are necessarily tentative and confined to recent years.

We shall begin, then, by considering the consumption of energy-producing foods.[14] At the outset, however, it is necessary to sound a warning lest the reader be tempted to place too much reliance upon individual figures. In the first place, consumption data on food are for the most part derived by adjustment of output estimates for imports, exports, changes

[14] The derivation of the estimates presented in the remainder of this chapter is described in detail in Appendix B.

in stocks, and use for nonfood purposes; they suffer therefore from possible weaknesses not only in the output estimates, but in these adjustments as well. In the second place, we have found it necessary to assume that the composition of each food item remained unchanged over the period reviewed, although this cannot have been exactly the case. There is evidence, for instance, that the tendency toward leaner meats may have altered the relative proportions of protein and fat. In the third place, the reduction of the animal carcass (in the case of meat) to fats and proteins in itself depends upon estimates of unknown reliability. Finally, waste, for which we have not been able to allow, undoubtedly occurs at numerous points. Nonfood by-products and the inedible portion of foodstuffs have indeed been excluded, but no allowance has been made for losses in transportation, storage, processing or retailing, in the kitchen or on the table. Our estimates really relate therefore to potential consumption rather than to actual ingestion. For all these reasons changes over long periods of time are to be regarded as more significant than absolute amounts shown for particular years.

First, as to aggregate consumption by weight, official estimates are available for the per capita [15] daily consumption of all foodstuffs in pounds,[16] and this series is shown in Table 21 and Chart 38. It appears, as might be expected, that per

[15] To facilitate clarity of exposition, we have refrained from correcting the population figures used here for changes in age or sex composition. See discussion below.

[16] U. S. Bureau of Agricultural Economics release, "Consumption of Agricultural Products" (1941). The actual poundage eaten is overstated by this series (Table 21, column 1, below), for such items as manufactured dairy products (except butter), canned and dried fruit, fruit juices, and canned vegetables were reconverted by the compilers into their unprocessed equivalents. In the case of dairy products this procedure inflates the total by more than 80 pounds per capita per annum, and in the case of fruit and vegetables the overstatement is almost equally large. An additional overstatement in the Department of Agriculture series reproduced here results from the failure to exclude corn used in the manufacture of nonfood products. On the other hand these data (like all others in this chapter) omit the consumption of fish. A rough check indicates the total overstatement to be around 10 percent.

TABLE 21

DAILY PER CAPITA[a] FOOD CONSUMPTION, 1897–1939

Year	Pounds[b]	Proteins	Fats	Carbo-hydrates	Calories
		(grams)			
Average, 1897–1901	..	100	132	502	3,590
1909	5.12	96	131	481	3,490
1910	5.15	94	129	478	3,453
1911	5.04	93	135	471	3,471
1912	5.18	95	132	484	3,506
1913	5.08	93	132	478	3,471
1914	5.06	92	136	467	3,453
1915	5.04	89	130	457	3,353
1916	4.94	89	136	457	3,410
1917	5.00	91	131	468	3,410
1918	4.87	88	136	438	3,324
1919	4.87	87	133	451	3,349
1920	4.87	87	128	451	3,306
1921	4.68	83	128	433	3,213
1922	4.99	87	132	462	3,388
1923	4.95	87	139	440	3,359
1924	4.99	87	141	452	3,425
1925	4.93	87	139	445	3,377
1926	5.00	88	140	461	3,457
1927	4.98	88	141	447	3,411
1928	5.01	88	142	467	3,498
1929	5.02	87	144	451	3,449
1930	4.93	87	142	438	3,378
1931	4.90	86	142	439	3,382
1932	4.80	85	141	423	3,299
1933	4.71	83	141	407	3,227
1934	4.73	83	139	420	3,265
1935	4.85	81	128	415	3,136
1936	4.91	84	136	418	3,230
1937	5.01	85	138	411	3,223
1938	5.10	85	139	415	3,252
1939	5.11	86	145	415	3,306

Source: Appendix B, except as otherwise noted. Calendar year data.

[a] Based on population as of midyear, unadjusted for sex and age differences.

[b] Based on U. S. Bureau of Agricultural Economics, *Consumption of Agricultural Products* (Washington, 1941), p. 13; coffee and tea excluded.

capita consumption by weight is remarkably stable. In only one year during the period 1909–39 did the series deviate by as much as 5 percent from its 31-year average. However, the actual number of pounds of food consumed is a somewhat misleading concept which may hide as much as it reveals. Weight, for example, is often due to water content. Few cuts of meat contain less than 40 to 50 percent of water: as purchased, a medium fat loin of beef contains over 50 percent, and a similar loin of pork over 40 percent of water.[17] Fruits and vegetables, of course, are even richer in water. The constitution of the more solid foods varies greatly also, and here the more important question relates to the amounts of proteins, vitamins and other nutrients they can supply. Indeed the popular notion of "heavy" foods refers to digestibility or to calorie content rather than to weight.

The logical procedure, then, is to convert each variety of food consumed into its equivalent in terms of each of the different nutrients of which it is composed. The pioneer study in this field was published in 1920 by Raymond Pearl.[18] Although aware of the importance of vitamins, Pearl was forced to confine his statistical treatment to the estimation of proteins, carbohydrates and fats in the diet, which he did for the years 1911–12 through 1917–18. For these years he found a per capita consumption of about 3,400 calories per day, but the period he considered was not long enough for his figures to reveal any significant downward trend in the intake of calories. Since the publication of Pearl's findings the efforts of the Department of Agriculture have led to a considerable improvement in the data on food consumption. In the present chapter it is our purpose to develop estimates for the per capita consumption of proteins, carbohydrates and fats an-

[17] Atwater and Bryant, *The Chemical Composition of American Food Materials*, pp. 21, 38.

[18] *The Nation's Food* (W. B. Saunders, Philadelphia, 1920). A comparison between our estimates for per capita calorie consumption and those given by Pearl will be found in Appendix B.

nually, back to 1909; in addition we present the best estimate we can make for the period 1897–1901.

For years since 1909 we were able for the most part to rely upon official estimates of food consumption; but where necessary for this period, and for all foodstuffs in 1897–1901, we developed estimates of our own. The next step was to convert each foodstuff into its equivalent of proteins, carbohydrates and fats. For this purpose we supplemented Atwater's data with other estimates of food value where this procedure seemed desirable. The aggregate amounts of each of the three kinds of nutrient were then converted into calories with the following conversion factors:

1 gram of protein	= 4 calories
1 gram of fat	= 9 calories
1 gram of carbohydrate	= 4 calories

These take into account energy losses incurred in the course of digestion [19] and are therefore slightly lower than the factors used by Pearl. The results of the calculation are shown in Table 21 above; the consumption data and conversion factors are presented in Appendix B. Since in the field of fuel elements we are less interested in absolute than in relative levels, and since the composition of the population in terms of energy-requirement units has not altered sufficiently to affect year-to-year changes in per capita consumption appreciably, we have not recomputed population data on the basis of age and sex composition.[20]

As we can see at a glance from Table 21 and Chart 38, per capita calorie consumption has decreased materially over the past few decades. In terms of selected 5-year averages, as shown in Table 22, the reduction between 1897–1901 and

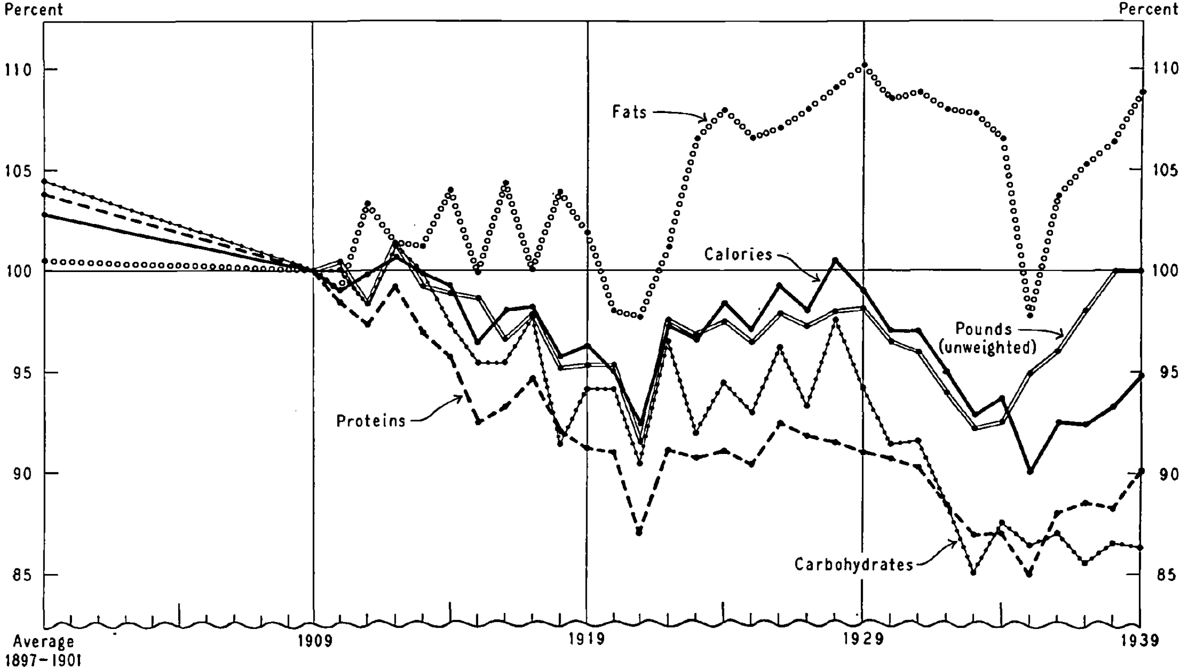
[19] See Sherman, *Chemistry of Food and Nutrition*, pp. 127-28.

[20] From tests we have made it appears that for the last four decades a correction factor of .81 will express satisfactorily the actual population in terms of requirement units. (Such a unit represents the estimated average requirement for males age 20-59.) See also discussion below, pp. 157-58.

Chart 38

FOOD CONSUMPTION PER CAPITA

(1909 : 100)



For source and notes see Appendix D

1935–39 has amounted to about 10 percent.[21] However, when we not only compare the initial and final period but observe the year-to-year changes, we discover that the diminution in consumption has not been of a continuous nature; for we can distinguish four stages, two of decline, 1899–1921 and 1928–35, and two of increase, 1921–28 and 1935–39. In fact consumption of calories varies with business activity, and exhibits rather clear cyclical movements. But it is subject also to a declining trend, for per capita calorie consumption is lower in 1935–39 than in earlier quinquennia (Table 22).

TABLE 22
CALORIES
Daily per Capita Consumption

Period	*Calories*
1897–1901	3,590
1909–1913	3,478
1917–1921	3,320
1925–1929	3,438
1930–1934	3,310
1935–1939	3,229

Source: Table 21, above.

Comparing per capita figures for tonnage and for calories in index form (Chart 38), we find the two moving together —with a slight tendency for calories to exceed tonnage both on the downgrade and on the upgrade—until 1934; in 1934 the two indexes part, the calorie index remaining stable and the tonnage index rising very steeply. In fact, from 1933 to 1939 per capita calorie consumption rises only 2.4 percent, while per capita tonnage consumption goes up 8.5 percent over the same period.

Anticipating the findings of subsequent sections we must

[21] About 12 percent in terms of "equivalent adult males." See below, pp. 157-58.

ascribe this divergence almost entirely to the increased consumption of fruit and vegetables, low in calorie content, high in weight.[22] One is naturally tempted to relate this recent change in diet to consumer education, but discussion of this aspect must be deferred to the following section.

Summarizing, we may say that a decided decrease in per capita calorie consumption, amounting to roughly 10 percent, is evident for the period 1899–1939, and that even during the years of highest post-war consumption, 1925–29, per capita calorie intake remained 5 percent below the 1899 level. As the data for the most recent years demonstrate, a measure of consumption by physical weight may be inadequate as a gauge of calorie intake when there are shifts in the selection of foods. In terms of weight of food consumed we eat about as much as did our grandparents; but we get along with 10 percent less calories. It is interesting to inquire briefly as to the factors that may have brought about this change.

There is naturally no way of establishing a definite causal link between changes in our mode of living and shifts in our demand for foodstuffs, nor is it feasible to subject any of the motivating factors to a rigid statistical test. Nonetheless, it is possible to outline major changes in the sociological factors, and to compare the results they would be expected to yield with observed trends in food consumption. Indeed, this has so frequently been done in a general way that the influence upon diet of certain sociological factors may be regarded almost as axiomatic. There may, however, be legitimate doubt as to the relative importance of the factors involved, and in this field there is still ample room for speculation. We have to differentiate between influences upon the *amount* and upon the *kind* of food consumed; generally it is much easier to trace the source of quantitative change than of qualitative

[22] During the period 1933–39 domestic production of truck crops increased 36 percent, of noncitrus fruit 22 percent, of citrus fruit 74 percent; see Table 5 above.

shifts, though in a very strict sense the two are interrelated.

Among the factors that have led to a diminished consumption of calories we must count: (1) increased mechanization of productive operations, both in industry and in agriculture, and a consequent lessening of physical exertion; (2) relative decrease in the agricultural population whose calorie requirements tend to be relatively high (because of hard work, heat-losses through outdoor activity and poor provision for heating in buildings); (3) shifts in the occupational distribution in favor of clerical and other nonmanual employments involving less physical exertion (especially sedentary occupations); (4) reduction in hours of work; (5) improved heating in buildings and transportation facilities, preventing losses of body heat; (6) improved and expanded transportation systems, decreasing the need for walking. Other tendencies, such as decreased body weight per person,[23] may also have had their influence.

The diminished per capita consumption of calories in the United States is sometimes attributed also to the higher average age of the population, in addition to the factors already enumerated: in 1900 the median age was twenty-three, in 1940 twenty-nine. Since the energy requirements of persons sixty years of age and over are substantially below similar requirements for adults in the lower age groups, and since the percentage of old people in the population has been increasing rather rapidly, it might be thought that the decline in per capita calorie intake could be accounted for, partially at least, in this fashion. Surprisingly enough it appears, on the contrary, that when the energy requirements of the various age groups are taken into consideration the calorie needs of the population on a per capita basis have actually gone up

[23] Holbrook Working, "The Decline in Per Capita Consumption of Flour in the United States," *Wheat Studies*, Vol. II (Food Research Institute, Stanford University, 1926), p. 286.

during the last forty years.[24] This is because the decline in the percentage of children, whose energy requirements are also lower than those of young adults, more than outweighs the increased proportion of aged persons in the nation. If the estimated calorie requirements for different age groups are correct, therefore, the increase in the average age of the population cannot have lowered the per capita need for calories, but must actually have raised it between 2 and 3 percent.

The bearing of this result on the interpretation of the observable decline in per capita calorie intake is not completely clear. Only if actual calorie consumption by different age groups conformed to physiological requirements could we say that changing age composition had worked in the opposite direction, and that the observed decline was that much more significant. Though we cannot make a definite statement to this effect, it seems to have been what occurred. The adjustment of calorie consumption to actual needs appears to be more or less automatic. As Working has remarked, "the adjustment of the appetite to the needs of the body for energy-producing foods is so completely unconscious that most people, perhaps, are entirely unaware of its action." [25] In other words, if the physiological need for energy-producing foods declines, so also will their consumption.

While this line of analysis perhaps offers a rational explanation of the decline in the per capita intake of calories, it does little to clarify such shifts in food consumption as that

[24] Using Stiebeling's (H. K. Stiebeling and E. F. Phipard, *Diets of Families of Employed Wage Earners and Clerical Workers in Cities,* Circular No. 507, U. S. Department of Agriculture, 1939) requirement scale and applying it to the age and sex structure as revealed by successive population Censuses, we find that the population, adjusted to an "equivalent adult male" basis, grew 65.3 percent between 1900 and 1930 as against a 61.9 percent increase shown by the uncorrected population figures.

The ratios of corrected to uncorrected population are:

1900	*1910*	*1920*	*1930*
.809	.816	.816	.826

[25] Working, *op. cit.,* p. 281.

toward dairy products, and fresh fruits and vegetables. To such questions we now turn.

COMPOSITION OF THE CALORIE SUPPLY

Calories do not tell the whole story. We must now try to determine how the three groups of nutrient—proteins, carbohydrates and fats—share in supplying energy. The data pertinent to this question are shown in percentage form in Table 23, and the situation is depicted graphically in Chart 39. It will be seen that between proteins, carbohydrates and fats as

TABLE 23
CALORIES
Percentage Contributions of Proteins, Fats and Carbohydrates to Total Consumption

	1897–1901	*1909–13*	*1925–29*	*1935–39*
Proteins	11.1	10.8	10.2	10.4
Fats	33.0	34.1	37.0	38.2
Carbohydrates	55.9	55.0	52.9	51.4
TOTAL	100.0	100.0	100.0	100.0

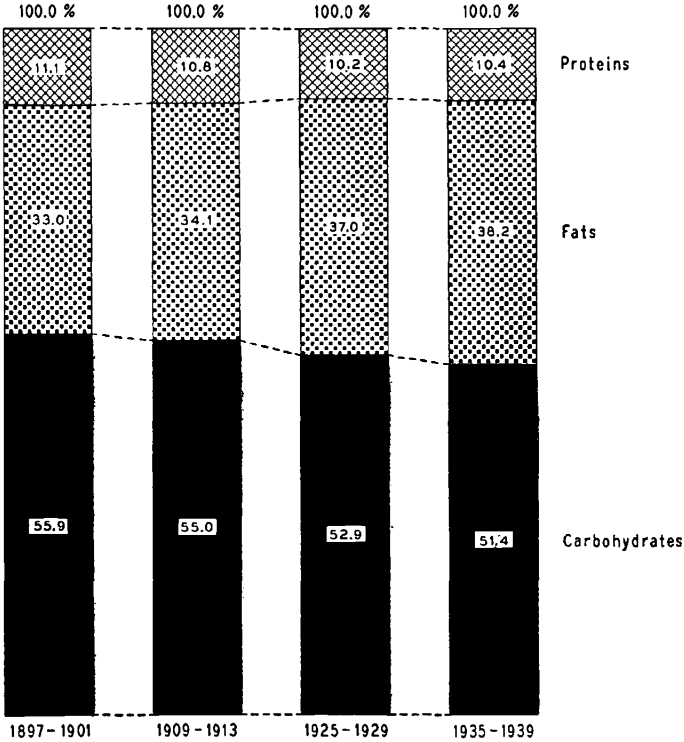
Source: Appendix B.

alternative sources of calories little or no substitution has occurred. The slight replacement of carbohydrates by fats is unimportant in terms of energy; but, as we shall see below, the changes that have caused this shift are closely connected with the availability of vitamins. They have some bearing also upon the balance of animal and plant proteins in our diet, insofar as the substitution of fat for carbohydrates reflects the replacement of cereals and sugar by milk, meat, and poultry.[26] That such a substitution has occurred, at least to some extent, is evident from a breakdown of total protein consumption, by groups. Here we see that a rising proportion

[26] Substitution of edible oils for cereals and sugar leaves the protein balance unaltered.

Chart 39

CALORIES: PERCENTAGE CONTRIBUTIONS OF PROTEINS, FATS AND CARBOHYDRATES



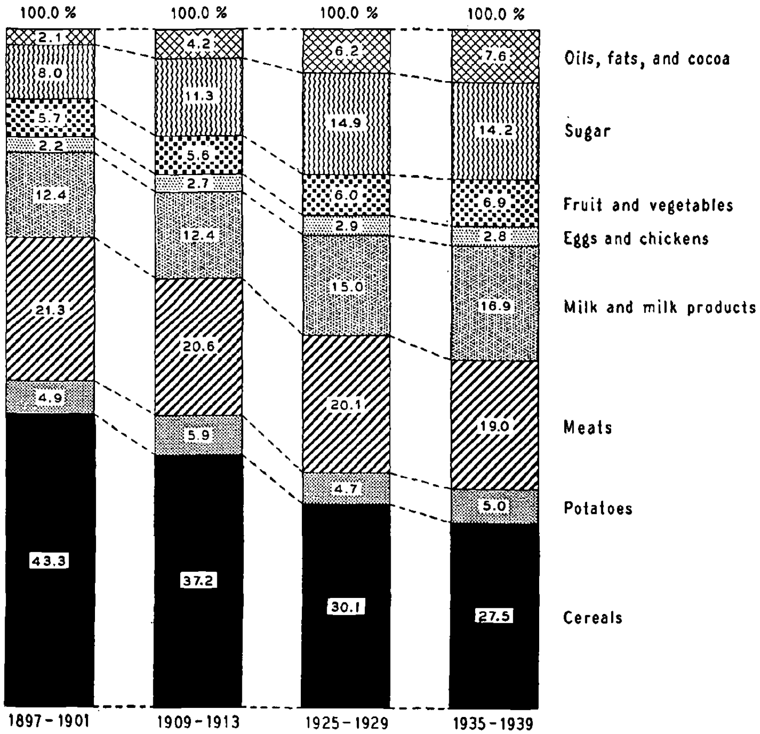
For source and notes see Appendix D

of protein has been accounted for by milk and poultry products, though the share of meat has remained fairly stable (Table 24).[27]

[27] As will be remembered, we have used a constant conversion factor for each meat animal. If the tendency toward leaner meats could be expressed in changing factors, it is likely that the protein derived from meats would also show an increase over the period under observation. As to the contribution of protein to total calories, between 10 and 11 percent, it should be remembered that we have omitted fish, a high-protein food. Its inclusion would probably raise total protein consumption some 3 or 4 percent, or the protein contribution .3 to .4 percentage points.

Chart 40

CALORIES: PERCENTAGE CONTRIBUTIONS OF DIFFERENT FOODS



For source and notes see Appendix D

At the turn of the century, animal-derived proteins contributed 44.3 percent to aggregate protein consumption. By 1909–13 the share had risen to 48.3, by 1925–29 to 54.6, and by 1935–39 to 56.8 percent.[28] We can think of no bias in our data so consistent that it would continue year by year to raise those particular items at the expense of the others. It may

[28] The League of Nations' Nutrition Committee of 1937 suggested that 50 percent of protein consumption be of animal origin. See *Final Report of the Mixed Committee of the League of Nations on the Relation of Nutrition to Health, Agriculture and Economic Policy* (Geneva, 1937), p. 60.

TABLE 24

PERCENTAGE CONTRIBUTIONS OF DIFFERENT FOODS TO CONSUMPTION OF CALORIES, PROTEINS, FATS AND CARBOHYDRATES

Period	*Cereals*	*Potatoes and Related Crops*	*Meats*	*Eggs and Poultry*	*Milk and Milk Products*	*Fruit and Vegetables*	*Sugar*	*Oils and Fats*	*Cocoa*
				CALORIES					
1897–1901	43.3	4.9	21.3	2.2	12.4	5.7	8.0	2.0	0.1
1909–13	37.2	5.9	20.6	2.7	12.4	5.6	11.3	4.0	0.2
1925–29	30.1	4.7	20.1	2.9	15.0	6.0	14.9	5.6	0.6
1935–39	27.5	5.0	19.0	2.8	16.9	6.9	14.2	6.8	0.8
				PROTEINS					
1897–1901	46.4	4.0	23.9	7.8	12.6	5.1	..	..	0.1
1909–13	41.2	5.1	24.8	9.6	13.9	5.0	..	..	0.4
1925–29	34.0	4.4	23.7	10.9	20.0	5.8	..	..	1.0
1935–39	30.7	4.6	23.7	10.3	22.8	6.5	..	..	1.4
				FATS					
1897–1901	4.5	0.3	56.2	4.2	27.5	1.2	..	5.9	0.2
1909–13	3.5	0.4	52.2	4.8	25.9	1.1	..	11.7	0.4
1925–29	2.4	0.3	47.7	4.8	27.7	1.1	..	15.2	0.9
1935–39	2.0	0.3	43.3	4.5	29.8	1.2	..	17.7	1.2
				CARBOHYDRATES					
1897–1901	65.7	8.0	..	..	3.3	8.6	14.4	..	0.1
1909–13	57.5	9.8	..	..	3.5	8.4	20.6	..	0.1
1925–29	48.9	8.2	..	..	5.1	9.1	28.3	..	0.3
1935–39	46.2	9.0	..	..	6.0	10.4	27.9	..	0.5

Source: Appendix B.

thus be concluded with some confidence that proteins of animal origin, which have been said to be of higher nutritive value,[29] have grown in importance throughout the four decades.[30]

As has been mentioned, the substitution of fat for carbohydrate has also been traceable, though to a much smaller extent, to the expansion of the use of edible oils and fats. Contributing less than 2 percent of all calories consumed in 1899, their share has risen to between 6 and 7 percent in recent years. In the fat balance sheet they have grown from 5.9 percent in 1899 to about three times that amount, matching almost exactly the reduction in the contribution of meats. If we could conclude that consumption has shifted from lard to vegetable oils, the significance of the change would be slight. If, however, the growth of oils has occurred partly at the expense of butter, the substitution has meant a deterioration of diet, since the vegetable oils—and they constitute the bulk of the group—contain no other nutritive elements.[31]

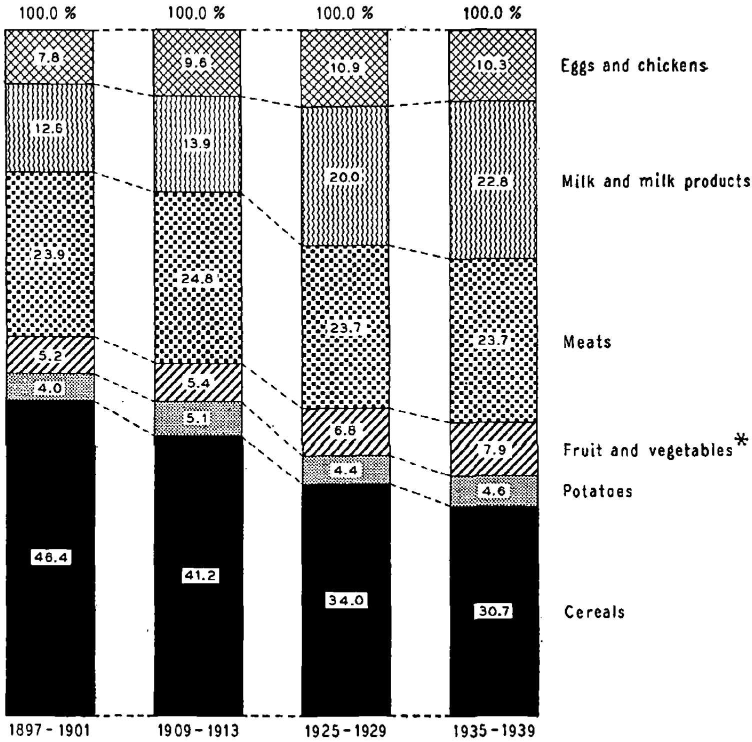
An interesting shift, best discernible in the composition of the carbohydrate supply, has been the substitution of sugar for cereals. From as much as 66 percent in 1897–1901, cereals have dropped to 46 percent of all carbohydrates in recent

29 McCollum, Orent-Keiles and Day, *The Newer Knowledge of Nutrition*, p. 564.

30 This result is consistent with the increased share of total farm output for which edible livestock products were responsible in 1935–39 as against 1897–1901, a share which had risen from 57.6 percent to 61.8 percent (see Table 2). Similar evidence is found in a comparison of the movement of the livestock index with that of crops (Table 3). The livestock index increased 56 percent from 1897–1901 to 1935–39 while the crop index rose only 39 percent over the same period.

31 The movements of our oil crop index—as we have shown in Chapter 3—are dominated by the production of cottonseed oil. The bulk of cottonseed oil in turn is consumed in edible products, and furthermore the bulk of the oils and fats used in foods consists of cottonseed oil. It is therefore interesting to compare the expansion in oil consumption with our output index. The latter increased not quite two and a quarter times from 1897–1901 to 1935–39 while the share of oils and fats in total fat consumption over the same period has risen threefold.

Chart 41
PROTEINS: PERCENTAGE CONTRIBUTIONS OF DIFFERENT FOODS



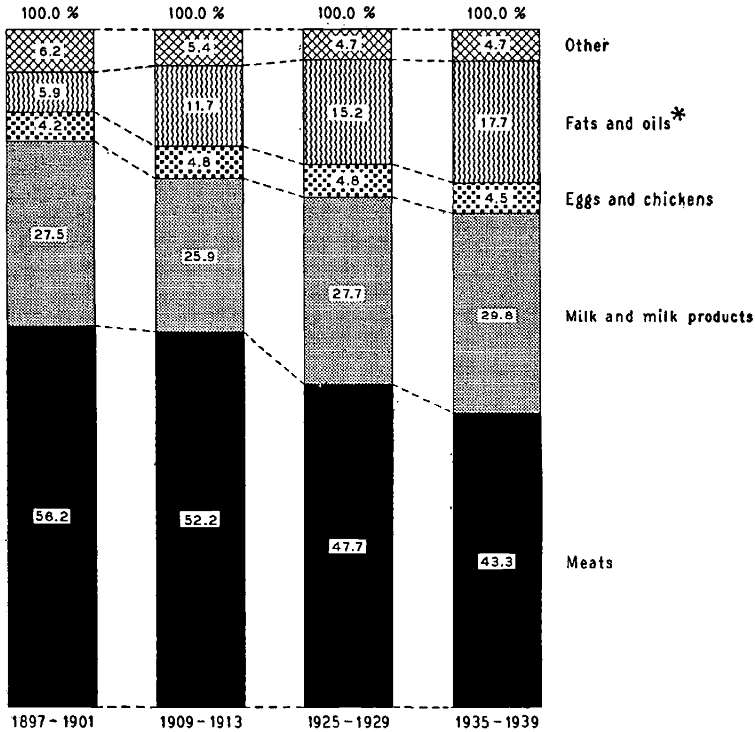
For source and notes see Appendix D

* includes cocoa

years.[32] Over the same period sugar has accounted for a growing share of aggregate carbohydrate consumption, a share that reached its maximum in the middle 1920's, when it amounted to over 28 percent, twice the proportion it had contributed at the turn of the century. For the past 15 years sugar has increased no further, and since 1935 has even shown a declining tendency whose significance cannot yet be assessed.

32 Rates of change in net output of grains, by kinds, are shown in Table 8 above.

Chart 42.
FATS: PERCENTAGE CONTRIBUTIONS OF DIFFERENT FOODS

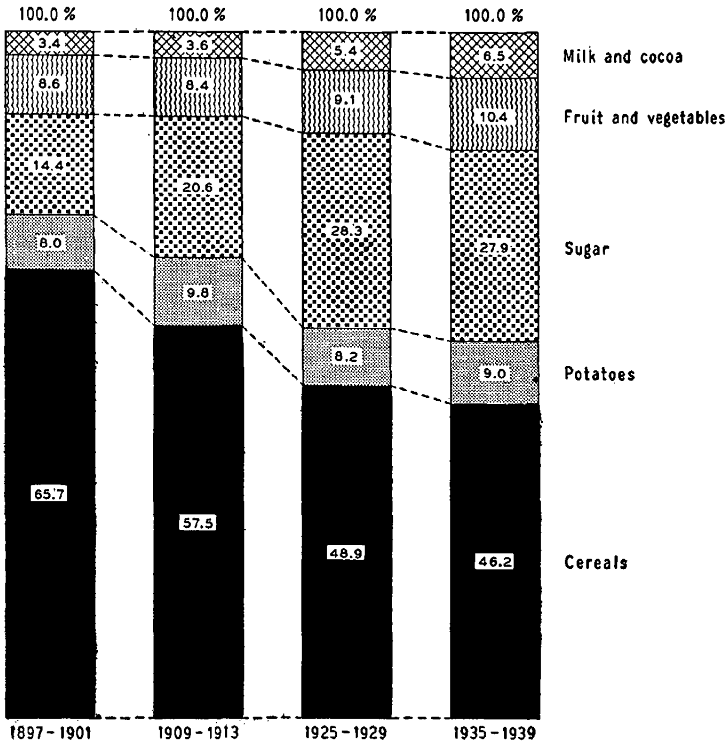


For source and notes see Appendix D

*excluding lard

Since 1900 cereals have declined more rapidly than sugar has risen, so that their joint contribution to the carbohydrate supply has decreased somewhat, from over 80 percent around 1899 to 75 percent in recent years. While the substitution of sugar for cereals must be considered detrimental to the nation's diet—since sugar lacks the protein and the small amounts of vitamins and minerals contained even in highly refined cereal derivatives—the falling share of the two items and their replacement by milk and milk products, and very

Chart 43
CARBOHYDRATES: PERCENTAGE CONTRIBUTIONS OF DIFFERENT FOODS



For source and notes see Appendix D

recently by fruit and vegetables, has been a salutary development. The increased representation of fruit and vegetables in the carbohydrate balance—from 8.7 percent in 1933 to 10.8 percent in 1939—must be appraised in the light of the very small carbohydrate content per weight-unit of product. By weight the increase in per capita fruit and vegetable consumption per annum was over 100 pounds between 1933 and 1939,[33] yet the resulting change in the percentage contribu-

[33] "Consumption of Agricultural Products," pp. 11-13.

tion of this group to carbohydrate consumption was very small. However, the nutritional importance of fruit and vegetables derives rather from their vitamins and minerals than from their calorie content.

It is evident that the decline in per capita intake of calories has been accompanied by an increased consumption of dairy products, fruit and vegetables, a development which nutritional experts agree represents a real improvement in diet. The explanation of this trend is more difficult than its recognition, and any attempt to find causes must take account of several diverse factors.

(1) A rising real income has created a demand for greater variety in diet. From many surveys we have learned that at any given time larger income is associated with diversification of food consumption, in which the so-called "protective" foods tend to replace the "heavy," or high-calorie, foods. There can be little doubt that these findings possess historical significance as well. It is noteworthy in this connection that increased vegetable consumption was advocated during the early years of this century because it offered variety of diet.[34] An interesting indication that a higher standard of living (plus ready availability of more expensive foods) will lead to diversified consumption—in the absence of nutritional guidance and even in the face of the consumer's own reasoning against what appear to be "luxuries"—is to be found in the testimony of a housewife as long ago as 1910:

> We are all grown luxurious; little by little it has come about, and we are almost unconscious that a change has been made. When I first began to keep house, ten years ago, we ate cereal, eggs and coffee for breakfast, with fruit occasionally instead of cereal; but now we must have grapefruit every morning, eggs

[34] C. F. Langworthy, "Green Vegetables and Their Uses in the Diet," *Yearbook of the Department of Agriculture, 1911,* pp. 439-52.

> and bacon and hot muffins. We are no better off as far as being nourished goes (sic), but we just somehow want it, and two grapefruit cost as much as did the whole breakfast ten years ago. Then, when I go to market and see fresh beans, cucumbers and spinach, I buy them without really stopping to think; so easily tempted are we.[35]

(2) Improvements in the distribution of perishable products, including transportation, storage, and handling, have made a larger variety of foods available to more people during a greater part of the year, and at lower prices. Yet ability to pay and availability of the newer foods are not of themselves conducive to adequate diet. The palate is not an infallible guide, as we learn from a mass of evidence collected during the past thirty years, obtained from comparative and historical studies of human populations and from experiments upon animals as well.[36] The impossibility of recognizing deficiencies of diet by common sense or intuition has been established only in recent years, and is perhaps not yet popularly admitted. Furthermore, deficiency diseases nowadays rarely advance beyond the subclinical stage, so that the majority escape diagnosis by the medical profession. Unless malnutrition is severe the symptoms are for the most part nonspecific and are apt to be diagnosed as chronic nervous exhaustion, constitutional inferiority and other such vague conditions.

It must be recognized also that in some ways industrial progress has led to a deterioration of our diet. Greater refining and bleaching of flour and the increased availability of sugar have tended directly or indirectly to make our diet

35 Massachusetts, *Report of the Commission on the Cost of Living* (Boston, 1910), p. 255.

36 For a summary of this evidence, see McCollum, Orent-Keiles and Day, *The Newer Knowledge of Nutrition*, Ch. XV; also Borsook, *Vitamins*, Ch. II.

less rich in certain minerals and vitamins.[37] This effect has been further enhanced by the increasing commercialization of agriculture. Foods formerly grown and consumed on the farm—cornmeal, molasses, etc.—have been sold for cash, and their place has been taken by commercially refined and nutritionally inferior products like white flour and sugar.[38]

(3) The effect upon popular dietary standards of progress in the science of nutrition is by no means clearly discernible. The state of popular education regarding food values has undoubtedly undergone some change within very recent years, but organized nutritional propaganda can hardly be said to antedate the later 1920's. Indeed, the "newer knowledge of nutrition" itself, though its isolated antecedents can be found before then, emerged as a body only in the third decade of this century. The modern science of nutrition is to be credited with providing us with suitable tools for the analysis of contemporary food consumption, but can hardly be said to have had much influence, at least until very recently, on the diet of the population at large. There is little doubt, however, that in the years to come our newly gained knowledge will be a major factor in determining our diet. Once again, war is acting as a ferment in speeding up and translating into reality a development whose existence had been largely confined to the textbook and the laboratory.

VITAMINS IN THE FOOD SUPPLY

So far as the authors are aware, no estimates of per capita vitamin consumption in the United States, based upon the dis-

[37] "One of the most important factors in lowering the quality of the diet of many millions of Western peoples is the excessive use of refined flour and other cereals, and sugar. There is no valid objection to the use of these foods in certain quantities, provided they are supplemented with sufficient amounts of protective foods, namely milk, eggs, leafy vegetables, and meats. The trouble is that this is not done." McCollum, Orent-Keiles and Day, *op. cit.*, p. 598. On the aspects of "enriched" flour, see A. E. Taylor, "Why Enrichment of Flour?" *Wheat Studies*, Vol. XVIII (Nov. 1941), pp. 77-108; and p. 187 below.

[38] Hazel Kyrk, "Home Economics," *Encyclopaedia of the Social Sciences*, Vol. IV (Macmillan, 1932).

appearance of food materials, have been published.[39] Nor is this omission in any way accidental. The field of vitamin research is newly opened, and the sum of the accurately established results at the disposal of the inquiring statistician is still small. The peculiar difficulty of constructing reliable estimates in this field is caused partly by the fact that the biochemist and the student of nutrition have not yet furnished the economist with all the data he would like to possess, and partly by two characteristics of vitamins themselves. For one thing, vitamins are present in most foodstuffs only in minute quantities, whereas in determinations of the calorific value of nutrients, substantially the whole of the material is accounted for. Proteins, carbohydrates and fats together constitute a large fraction of the total weight of the substance; the remainder consists chiefly of water and mineral elements. The possibility of errors in a food's reported content of these nutrients, or in its calorific value, is somewhat limited by this fact. The protein content of a pound of potatoes cannot of course be ascertained with mathematical exactitude, and there will always be some variation between one sample of potatoes and another. But the true value of the protein content of potatoes in general cannot possibly be as much as twice, or as little as half, its reported value; for to assume

[39] However, Stiebeling and Phipard (*Diets of Families of Employed Wage Earners and Clerical Workers in Cities*) offer estimates based upon family records of food expenditure. This treatment has the advantage that the point of measurement is as close to final ingestion as it can well be outside the laboratory; no account need be taken of losses in processing or distribution, and the task of evaluation in terms of vitamins is simplified. The disadvantage is the difficulty of judging the representativeness of the sample of family budgets. Unfortunately in the study quoted the authors do not give the conversion factors they used; this is all the more regrettable since the results are presented as single values rather than as ranges.

There is also a study of per capita vitamin (A and C) and mineral consumption in the United Kingdom. Though the emphasis of the study is on differences in diets by income levels, yet national food disappearance data were used to correct consumption estimates derived from budget studies. As in the case of the Stiebeling-Phipard study no details of estimation are supplied. J. B. Orr, *Food, Health and Income* (Macmillan, London, 1936).

errors of this magnitude would imply that the various investigators had been so careless as to neglect to weigh their samples of potatoes before they began their analyses. With vitamins, unfortunately, the situation is quite different, for they account usually for only a minute fraction of a percent of the total weight of the food material. It is entirely possible for one sample of a food to have several times the vitamin content of another sample of the same food. Further, small errors in the absolute amounts of vitamin reported in a biological or chemical assay may represent large errors in the percentage vitamin content attributed to the food sample.

The second difficulty in the estimation of vitamin consumption stems from the uneven distribution of vitamins among food materials. There are some foods, for example, whose individual consumption does not have to be worked out with any great accuracy in the computation of the total supply of, say, protein; but it may happen that their share of the total supply of one or another of the vitamins is so great that errors which are unimportant in other connections assume considerable significance. The consumption of liver and kidneys and of fish oils does not have to be estimated accurately when we are computing calories, yet each also contributes a substantial fraction of the total supply of the fat-soluble vitamins A and D. Again, individual fruits and vegetables vary markedly in the amount of vitamins they afford; here too consumption data that are accurate enough for many purposes are scarcely able to support attempts to estimate the vitamin supply. Vitamin content sometimes differs substantially, moreover, as between young and mature crops, or between different varieties of the same vegetable or fruit. These difficulties seriously reduce the precision of any estimates of vitamin consumption, and have in fact prevented us from offering any estimates at all in the case of vitamins C and D. Further, the absence of detailed data on fruit and vegetable consumption for years prior to 1919 precludes the construction of satisfactory estimates of the availability of vitamins during the early part of our period. We have therefore confined the estimates to very recent years.

There can be no doubt that the rather wide ranges reported for the vitamin content of the same foodstuff are to be charged partly to experimental error and partly to the necessity of comparing the results accruing from widely differing types of assay. But there is clearly also rather wide dispersion in the actual contents of samples of a single food, perhaps similar in other respects. Then, too, different portions of the sample specimen will contain varying quantities of vitamins; there is much more vitamin A, for example, in the greener parts of a head of lettuce than in the heart. Differences of this sort would matter less if the ranges in question could be interpreted, even in a very general way, as indicating fiducial limits for averages derived from them. But the number of determinations is too small, and the relative worth of different methods and different investigators too uncertain, to permit such a treatment even by workers much better acquainted with the laboratory aspects of the subject than the present authors. When methods of measurement have become more standardized and the number of determinations in the case of each foodstuff has been substantially increased, the interpretation of the range of the reported estimates as a significant indication of their dispersion would appear to be a more promising line of advance than it is at present.

Something must be said, too, about the question of losses. The estimates for proteins, carbohydrates and fats in the preceding sections almost certainly overstate actual intake by the body because we have not made adequate deductions for waste of the actual foodstuff in processing and distribution, in the kitchen and on the table. With the vitamins, however, and most notably in the case of vitamin C, losses may and do occur even though none of the foodstuff in question is wasted, through chemical disintegration in processing, storage or cooking. To give but one example, fresh snap beans have been observed to lose 42 to 65 percent of their content of vitamin C on storage for six days at a temperature of 1°-3° C., and as much as 58 to 81 percent at 21°-23° C.[40] Processing likewise affects vitamin content, particularly in the case of vitamin C which is easily oxidized when heated in contact with the air. Vitamins of the B group appear to be somewhat more stable,[41] and vitamin A is even less easily destroyed. We have not attempted to make any consumption estimates for vitamin C principally because of the large and uncertain losses of this kind.

Estimates for per capita consumption of vitamins A, B_1 (thiamin) and B_2 (riboflavin) are given in the upper half of Table 25. We compiled the data in the first line of the table under "original range" by taking first the minimum, and second the maximum, published estimate for vitamin value in the case of each food. While the range in the case of any given foodstuff cannot be interpreted as a measure of standard deviation, it is very improbable that the best value should lie at the same end of this range in the case of all foodstuffs, unless indeed the assay methods employed lead to a rather uniform bias. It seemed legitimate therefore to suggest a rather smaller range for our totals than that which results from the procedure just indicated. Accordingly, in the second line of Table 25, under "original range adjusted," are shown the same results, the range being arbitrarily halved, in order to allow for the effects of summation in reducing errors.

With some necessary reservations the estimates of per capita consumption for vitamins A, B_1 and B_2 may be compared with the available data on human requirements. These reservations are of two kinds. In the first place our consump-

[40] Sherman, *Chemistry of Food and Nutrition,* p. 339.

[41] The amounts of B vitamins remaining in cereals after milling may be further reduced in baking; nor have the effects of pasteurization in the case of milk been fully determined as yet. See Taylor, "Why Enrichment of Flour?"

TABLE 25

VITAMINS

Estimated Daily per Capita Consumption and Requirements, 1935–39

	A	B_1 (*thiamin*)	B_2 (*riboflavin*)
Consumption	(international units)	(international units[a])	(milligrams)
Original range	3,400 – 11,600	190 – 640[h]	1.64 – 2.20
Original range, adjusted[b]	5,500 – 9,500	300 – 530[h]	1.78 – 2.06
Requirements			
National Research Council, Committee on Food and Nutrition[c]	4,500[i]	480	2.1[i]
Stiebeling and Phipard[d]	5,700[i]	450[i]	1.7[i]
Mayo Clinic[e]		550	
Rose[f]		400 – 500	
Hogan[g]			2 – 3
Sebrell[g]			3

[a] For thiamin, 1,000 international units = 3 milligrams.

[b] The adjustment consists in halving the range reported in the preceding line. See discussion in text.

[c] U. S. Bureau of Home Economics, *Planning Diets by the New Yardstick of Good Nutrition* (Washington, 1941), Table I.

[d] H. K. Stiebeling and E. F. Phipard, *Diets of Families of Employed Wage Earners and Clerical Workers in Cities,* Circular No. 507 (U. S. Department of Agriculture, 1939), pp. 58-66.

[e] R. D. Williams, H. L. Mason, B. F. Smith and R. M. Wilder, "Induced Thiamine (Vitamin B_1) Deficiency and the Thiamine Requirement of Man," *Archives of Internal Medicine,* Vol. 69 (May 1942), pp. 721-38. These authors report a thiamin requirement of 0.5 mg. per 1,000 calories, which at 3,200 calories equals 550 international units.

[f] Quoted by E. V. McCollum, Elsa Orent-Keiles and H. G. Day, *The Newer Knowledge of Nutrition* (5th ed; Macmillan, 1939), p. 470.

[g] Quoted by H. C. Sherman, *Chemistry of Food and Nutrition* (6th ed; Macmillan, 1941), pp. 381-82.

[h] In reviewing the manuscript of this book, Dr. Russell M. Wilder of the Mayo Clinic reminded the authors that, next to vitamin C, thiamin is subject to greater losses in processing and cooking than are any of the other known vitamins, and suggested that our consumption estimates of this vitamin should be written down by at least a third on this account. Losses of thiamin in the milling of cereals have been allowed for in the calculations, but no account has been taken of losses in other forms of processing or of the destruction of thiamin in cooking. It may well be that our consumption data for thiamin are too high, and that some downward revision, as suggested by Dr. Wilder, would be in order.

[i] Data have been adjusted to the 1930 age and sex distribution of the population.

TABLE 26

VITAMINS

Percentage Contributions of Different Foods to Total Supply, 1935–39[a]

Food	A	B_1 (thiamin)	B_2 (riboflavin)
Milk and dairy products	29.5	20.4	56.4
Eggs	15.0	4.2	7.4
Lean meat, including chickens	.3	22.4	10.1
Meat organs	2.6	1.0	3.8
Cereals	0	14.2	5.3
Fruit	8.0	9.7	3.4
Vegetables	44.5	28.0	13.5
TOTAL	100.0	100.0	100.0

[a] The percentages in this table have been computed on the assumption that the contribution of each food was measured by the midpoint of the range of the vitamin content in each case.

tion figures must be regarded as maximum estimates. They represent measures of the potential supply of vitamins, and take no account of losses of foodstuffs in processing and distribution, or in the home, except that inedible portions of eggs, fruits, and vegetables have been excluded (see Appendix Table B-4). Moreover, losses less serious than in the case of vitamin C may occur through chemical disintegration of vitamins B_1 and B_2, and to a lesser extent of vitamin A, before the food is assimilated. Finally, since the consumption estimates are per capita averages for the entire United States, they take no account of the maldistribution of the vitamin supply which no doubt exists, as between regions, income groups, or other divisions of the population.

The comparison also involves reservations on the side of human requirements. The problem here is primarily a physiological one, and is made no easier by the rather indeterminate character of the information available. Different authorities have focused attention on diverse concepts, such as minimum, normal, standard and optimum requirements.

Sometimes the same, or apparently the same, concept has elicited different estimates. Furthermore, the case of vitamins differs from that of energy-supplying nutrients. For the latter an upper limit exists beyond which the individual may be said to be overeating. In the case of most of the vitamins, however, there appear to be no upper limits beyond which intake becomes definitely harmful.[42] Thus, extensive research, so far restricted to animals, suggests strongly that consumption of various vitamins in quantities two to four times as great as have been generally considered adequate will confer increasing (though not proportionately increasing) benefits on human beings. These benefits appear to be connected with greater resistance to disease, lower death rates throughout the life cycle, and a lengthening of the period generally called "prime of life." [43] For this reason it is premature to assume upper limits to such quantitative intake of vitamins as may be deemed optimal, and our consumption estimates must be appraised in the light not only of minimum requirements but also of ranges many times the minimum. Indeed, vitamin requirements are usually set somewhat above the minimum level that will secure apparent health; for the danger that we may consume too little seems greater than the risk that we may consume too much.

> . . . *optimal diet,* or even optimal intake of an individual factor, is in most cases an *ideal* or an *ultimate* goal which we cannot yet define in precise quantitative terms. . . . It may frequently be desirable to second McCollum's teaching that in nutrition there is or may be an important difference between the merely adequate and the optimal; but it is never desirable to call a diet optimal merely because it is better than barely adequate. . . .[44]

[42] The intake of vitamin D does appear to have such an upper limit, however. See McCollum, Orent-Keiles and Day, *The Newer Knowledge of Nutrition,* pp. 386-87.

[43] Sherman, *Chemistry of Food and Nutrition,* Ch. XXX, *passim.*

[44] *Ibid.,* p. 253n. Italics in original.

The tentative figures we have been able to collect for the daily requirements of each vitamin are shown in the lower half of Table 25. At first sight consumption does not seem to be noticeably below the level of the figures quoted for requirements, at least in respect of the three vitamins shown here. But this conclusion must be qualified by the two important reservations suggested above. As already explained, the consumption estimates relate to the potential supply available in our food rather than to actual intake, and make no allowance for losses in distributive channels or in the home. It is equally obvious that data for per capita consumption must conceal a significant dispersion among individuals.[45] No doubt some dispersion exists in the vitamin requirements of different persons, in addition to that conditioned by age and sex differences. On the other hand we have no reason to expect that the two variables—consumption and requirements—are closely correlated among individuals. In fact variations in consumption are likely to be found mainly on a regional basis, to correspond with the distribution of income, and perhaps to be influenced by a wide range of sociological characteristics which cannot accurately be specified. In the light of these reflections the situation revealed by Table 25 is less satisfactory. Any excess of requirements over per capita consumption as indicated in that table may easily be wiped out by losses in processing. And, finally, an equivalence between per capita consumption and physiological requirements could be considered satisfactory only if the vitamin supply were much more evenly distributed than we have any reason to suppose is the case. We must conclude in fact that our data

[45] In this connection it is interesting to note the results reached in a study of nutrition in Britain. In this study average consumption was estimated for each income group. We combined the results into a per capita average for the entire country by using as weights the estimated population in each income group. In this way it was found that, although average vitamin A consumption was only 6 percent below the assumed requirement, yet one half of the population consumed diets which were deficient in vitamin A (Orr, *Food, Health and Income,* Table VII).

do nothing to disprove the suggestion that a sizable sector of the population subsists on diets which possess no satisfactory margin of safety, and that a fraction, perhaps even larger, fails to obtain adequate amounts of vitamins even to insure a minimum standard of "good" nutrition.[46] Secretary Wickard's recent assertion that "at least three-fourths of us do not have really satisfactory diets" [47] does not appear entirely unreasonable. A more specific evaluation has recently become available in a survey undertaken by the Food and Nutrition Board of the National Research Council:

> Malnutrition is accompanied by manifold signs and symptoms, diverse in nature, and to the casual observer their origin and significance are not always apparent. Some types of malnutrition are strikingly obvious to every one, some are apparent only to the physician who looks for them and some are vague and elusive even to the careful observer using the most accurate specialized techniques. If the first group alone is counted the prevalence of malnutrition will be recorded as low, almost negligible. If the second group is counted it will be recorded as high. If the third group is included then the rate will be sufficiently high to occasion genuine concern.
>
> The evidence at our disposal warrants the conclusion that dietary inadequacies and malnutrition of varying degrees are of frequent occurrence in the United States and that the nutritional status of an appreciable part of the population can be distinctly improved. If optimal nutrition is sought, not mere adequacy, then widespread improvement is possible.[48]

Let us assume, in order to allow for losses and for the dispersion of individual intakes, that an adequate dietary situation, if reflected in levels of apparent per capita consump-

[46] Stiebeling and Phipard, *Diets of Families, passim.*

[47] C. R. Wickard, "Agricultural Policy and National Nutrition," address at the National Nutrition Conference for Defense, Washington, May 27, 1941.

[48] Jolliffe, McLester and Sherman, "The Prevalence of Malnutrition," p. 950.

tion of the kind we have computed, would run somewhat in excess of figures quoted for requirements. In that case the consumption of vitamin A appears to be least inadequate, particularly since losses to be allowed for are probably not serious.[49] For both thiamin and riboflavin the picture is less satisfactory. Some years ago the thiamin consumption reported in Table 25 might have been considered adequate, but recent determinations have suggested a higher requirement level than used to be reported for this vitamin. If, as appears likely, the daily requirement is as high as, or higher than, 500 international units, thiamin consumption is clearly inadequate. This conclusion is strengthened by the fact that thiamin is very susceptible to losses in cooking for which no allowance has been made in the consumption figures.[50] The situation in regard to riboflavin appears even more unfavorable. Recent investigations suggest that a daily intake of between two and three milligrams is necessary, although 1.7 milligrams is accepted as a minimum requirement by Stiebeling and Phipard.[51] Our own consumption estimate is around 2 milligrams, without any allowance for losses prior to ingestion. It seems probable, therefore, that the average American diet fails by a substantial margin to supply riboflavin in adequate amounts. Stiebeling and Phipard concluded, in part at least because of the low requirement with which they reckoned, that "riboflavin appears to be fairly well supplied in average

[49] Our estimates omit fish and nuts as well as some vegetables particularly rich in vitamin A. These omissions, due to the absence of satisfactory data, are revealed, by a rough check, to lead to only a negligible underestimate, since the items involved are consumed in proportions exceedingly small compared to other foodstuffs. On the basis of a trial estimate we feel confident that for none of the vitamins do these omissions lead to a downward bias in our figures of more than 5 percent, if that much. An item like peanut butter, for example, outstandingly rich in both B_1 and B_2, probably contributes no more than three international units of B_1, per day, compared to the total consumption range of 190-640 units per day. The omission of fish affects mainly vitamin A, the intake of which seems least deficient regardless of this omission. See Appendix Table B-3, notes.

[50] See note h to Table 25.

[51] See also Sherman, *Chemistry of Food and Nutrition,* p. 382.

diets." [52] With this exception our results are compatible with the conclusions reached by these authors. The study in question revealed that among white families arrayed according to the vitamin A content of their diet the lowest quarter consumed 2,000 international units or less. For vitamin B_1 the corresponding value was 400 international units.

How may this situation be improved? Table 26 shows the large contributions of dairy products and vegetables to the current supply of all three vitamins for which we have been able to assemble data. In the case of vitamin B_1 (thiamin), meat and cereals are also important sources of supply. In fact the distributions in the table serve to underline the familiar advice that we should do well to substitute dairy products (including milk) for other sources of protein, and to eat more vegetables.[53] The availability of thiamin could be increased further by the substitution of wholewheat flour for white flour, without increasing the total intake of cereals. For example, if all wheat flour were wholewheat, daily per capita thiamin and riboflavin consumption would be raised to 520-770 units and 1.94-2.32 milligrams respectively (adjusted range: see Table 25 above). A successful attack on the problem of losses of vitamins B_1 and B_2 in milling could evidently achieve substantial results without any increase in farm output. As an alternative hypothesis, we may take the increases in consumption which the Department of Agriculture has suggested as essential if the nation as a whole is to enjoy a "good" diet (see pp. 24-25 above). If we assume that there would be no offsetting reductions in the consumption of other foods, the effect of the increases mentioned would be roughly to raise daily thiamin consumption (adjusted range) from 300-530 to 360-620 international units, and riboflavin consumption from 1.78-2.06 to 2.14-2.50 milligrams. Though this would evidently represent a substantial improvement, when checked

52 *Diets of Families,* p. 99.

53 Also, of course, more fruit, primarily for the sake of vitamin C.

against requirements (Table 25) even these levels leave but a narrow margin of safety. In the case of vitamin A, the most readily available sources of supply are the fish liver oils. These are not consumed in any quantity in a normal diet, and have been omitted from our estimates; they are of course easily obtainable as special preparations. The other vitamins, too, can be bought in any drug store. Yet it is doubtful whether special preparations are, even apart from questions of cost, an adequate substitute for a balanced diet, however valuable they may be in pathological cases of vitamin deficiency. This is a question to which we shall return in the final section of the chapter.

MINERAL ELEMENTS IN THE FOOD SUPPLY

The task of estimating per capita consumption of minerals is confronted by difficulties not dissimilar to those discussed in connection with the vitamin supply. Both the mineral content of individual food materials and the mineral requirements for human well-being are somewhat more clearly established than in the case of vitamins.[54] Although, as with vitamins, many individual chemical elements comprise a minute fraction of one percent of total food weight, they are much easier to assay and they are not subject to chemical disintegration through storage or cooking. On the other hand a new qualifying factor enters our estimates in the guise of "biological availability." [55] Specifically, although we can compute more confidently the daily consumption of a given mineral eaten as part of a given food, it is frequently impossible for the biologists to tell us with any assurance what fraction of the mineral intake is actually utilized by the body. This difficulty arises in part because minerals are more available in some forms than in others, and in part because some min-

[54] See, however, McCollum, Orent-Keiles and Day, *The Newer Knowledge of Nutrition*, pp. 187-88, on changing mineral content of plant food.

[55] *Ibid.*, pp. 164-68; Sherman, *Chemistry of Food and Nutrition*, pp. 272-73.

erals require the cooperation of other substances for their absorption, notably vitamin D in the case of calcium. It is impossible to take account of these qualifications here,[56] and for this reason our data no doubt offer what are in reality maximum estimates. Furthermore, an ideal treatment of the problem should relate the intake of calcium, for example, to the availability of phosphorus, vitamin D and perhaps also magnesium.[57]

TABLE 27

MINERALS

Estimated Daily per Capita Consumption and Requirements, 1935–39

	Calcium	*Phosphorus*	*Iron*
	(grams)	(grams)	(milligrams)
Consumption	.83	1.31	12.2
Requirements per person[a]	.86	1.24	13.3

[a] These requirements were computed from H. K. Stiebeling and E. F. Phipard, *Diets of Families of Employed Wage Earners and Clerical Workers in Cities*, Circular No. 507 (U. S. Department of Agriculture, 1939), Tables 30, 31 and 33, on the basis of age and sex distributions from the 1930 Census. Allowances computed in accordance with the recommendations of the National Research Council (Table 25, note c) differ slightly—calcium: .92 g., and iron: 11.7 mg. The lower iron requirement is stressed also by H. C. Sherman, *Chemistry of Food and Nutrition* (6th ed; Macmillan, 1941), p. 288, where 12 mg. is considered sufficient.

Estimates for the per capita consumption of calcium, phosphorus and iron are presented in Table 27 and compared with generally accepted requirements. With the above qualifications in mind, we must conclude that the average American diet is almost certainly deficient in all three minerals studied. For, as in the case of riboflavin, estimated average daily consumption is at best equal to the estimated daily requirement. When we allow for losses both in distribution

56 However, we have treated the calcium content of spinach as nil for dietary purposes, in spite of the fact that it undoubtedly contains this element (see Sherman, *op. cit.*, p. 272).

57 Sherman, *op. cit.*, Ch. XIV; McCollum, Orent-Keiles and Day, *op. cit.*, Ch. VII.

TABLE 28

MINERALS

Percentage Contributions of Different Foods to Total Supply, 1935–39[a]

Food	*Calcium*	*Phosphorus*	*Iron*
Milk and milk products	77.5	38.2	8.9
Eggs	2.9	7.0	10.3
Lean meat, including chickens and turkeys	1.6	16.7	20.4
Meat organs	[b]	0.9	2.9
Cereals	4.5	19.7	25.5
Vegetables	9.4	11.9	24.0
Fruit	3.3	2.6	6.7
Cocoa	0.7	3.0	1.2
TOTAL	100	100	100

[a] It is interesting to compare this table with a similar one, compiled for the United Kingdom by J. B. Orr, *Food, Health and Income* (Macmillan, London, 1936), Table VIII, even though not all the items are strictly comparable. The left-hand figures refer to the lowest income group, the right-hand figures to the highest income group.

	Calcium	*Phosphorus*	*Iron*
Milk and cheese	61.9–68.4	22.3–34.3	3.1– 5.2
Eggs	2.2– 2.6	2.6– 4.3	3.7– 6.4
Meat	2.1– 1.6	17.3–19.0	24.3–29.6
Fish	.. ..	2.3– 6.1	1.2– 3.2
Cereals	14.7– 5.8	30.6–16.4	30.9–18.4
Vegetables	13.9–15.6	18.5–14.6	26.1–21.7
Fruit	2.8– 3.6	2.5– 2.8	6.7–12.5

[b] Less than 0.05.

and in the home, and for the dispersion in individual consumption, it is plain that a large fraction of the population must consume less than its requirements. Again these results are in line with the conclusions of Stiebeling and Phipard, who found that half of the white families observed subsisted on diets below both the calcium and the iron allowance,[58] with a somewhat more favorable situation in regard to the

[58] If the National Research Council's iron and calcium allowances are nearer the truth (see Table 27, note a), the iron situation is not quite as unfavorable as it would otherwise seem, whereas calcium consumption presents an even less satisfactory picture.

supply of phosphorus. This latter finding is confirmed by our own data. It may be noted that phosphorus intake is apparently more than one and a half times calcium consumption, which is to be regarded as a safe ratio.[59]

Table 28 suggests that improvement of our diet in respect of calcium must depend largely upon an expansion in the production of dairy and poultry products, while for phosphorus and for iron in particular a change in the processing of wheat is needed to retain these minerals. It is worth considering that if all our flour were wholewheat, daily consumption of phosphorus would amount to about 1.93 instead of 1.39 grams, of iron to about 24.6 mg. instead of 13.7 mg.

FOOD AND AGRICULTURAL OUTPUT

It is abundantly clear from the data we have presented in preceding charts and tables that past and present shifts in our national diet have, with two exceptions, led to an improvement. The two exceptions have been the shift from cereals to sugar and from animal fats to vegetable oils. Although the shift toward sugar has come to a halt, and has been replaced by a slight contrary movement, the increasing use of vegetable oils has gathered momentum in recent years. This is an unfortunate change only so far as butter has been replaced. If, as is probable, the shift reflects primarily an increased consumption of vegetable salads, it may be viewed as a concomitant of a thoroughly desirable development.

All other shifts, such as the continuous increase in the consumption of milk, fruit and vegetables, together with the steadiness in egg and poultry consumption, have been toward foods rich in vitamins and minerals; *within* the fruit group the rise of the citrus family—already noted as outstanding in growth among our production series—at the expense of apples has effected a notable increase in our consumption of vitamin C. Similarly, the change in the utilization of milk,

59 McCollum, Orent-Keiles and Day, *op. cit.*, pp. 172-75.

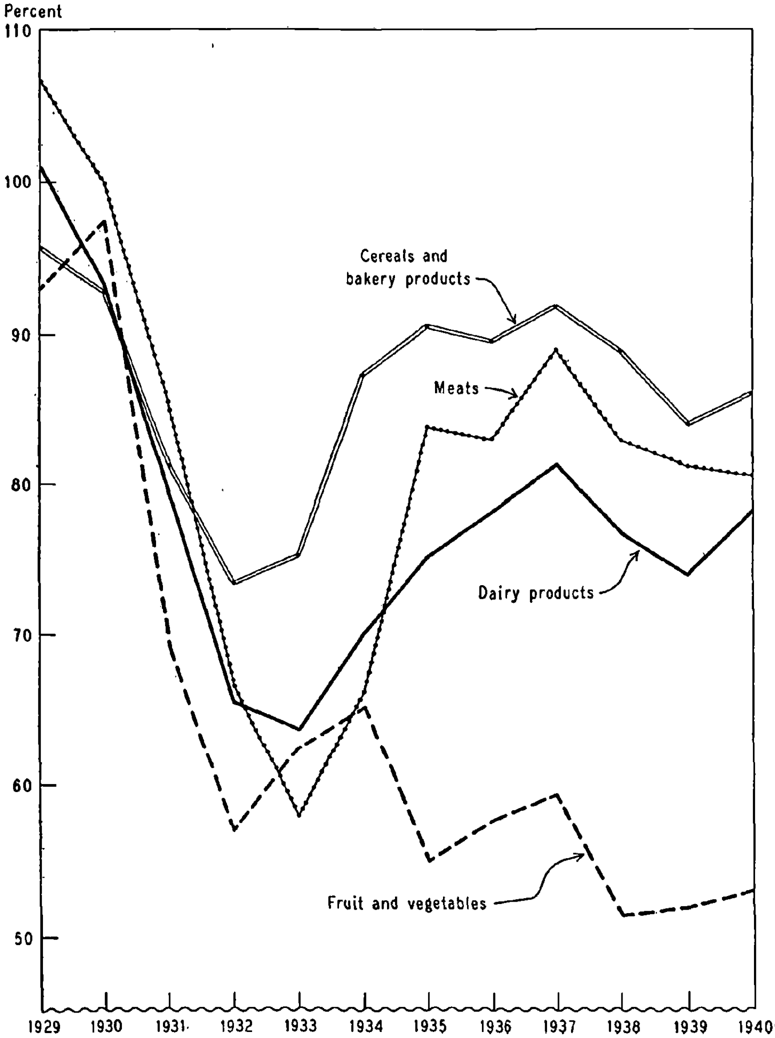
from butter to fluid milk, has been beneficial in making available vitamins of the B-complex, which are not contained in butter, as well as calcium.

On balance, our findings suggest that actual changes in diet have developed essentially along the lines recommended by the nutritionist; even though the growth in the consumption of fruit and vegetables is of recent origin, it is not too early to assume that the level reached will probably be maintained if not surpassed in the future. It may be that increased consumption in this field has been brought about in part by large-scale advertising,[60] based in its turn on scientific findings, and facilitated by a sagging price structure, owing to increased volume. For example, calculated on the basis of 1925–29:100, retail prices of fruit and vegetables by the end of 1934 were lower than those of any other food group and, with a minor interruption, continued to decline until November 1940, by which time the price index had dropped to 48. At the same time retail price indexes of other foods stood at 82 for meats and eggs, 80 for dairy products, 59 for fats and oils, 84 for cereal and bakery products, and 78 for sugar (Chart 44). Clearly, then, developments in the price pattern of agricultural products have been instrumental in calling forth the shifts in consumption that have been urged by the nutritionists.

Future improvement of the food supply does not depend upon any increase in the calorie intake, or upon greater consumption of proteins, carbohydrates or fats as such. It may be expected to come rather from a substitution of sources of carbohydrates and fats rich in vitamins and minerals for sources poor in these protective nutrients: shifts from sugar and white flour to wholewheat flour as a source of carbohydrates, and from vegetable oils to dairy products as a means of obtaining fats. Additions of fruit and leafy vegetables, low

[60] The producers of citrus fruit publicized the high vitamin content of their crop as early as 1922.

Chart 44
INDEXES OF RETAIL FOOD PRICES, 1929 - 40
(1925 - 29 : 100)



For source and notes see Appendix D

in calories but rich in vitamins and minerals, would also enhance the health-giving properties of the foods we consume. Finally the "enrichment" of existing foodstuffs, such as flour, may play a part.[61]

Our estimates of food consumption have taken no account of commercial preparations of vitamins and minerals which have come to be widely advertised by their manufacturers. The scope of this chapter has been deliberately confined to the study of foodstuffs as such, and we have given slight consideration to individual nutrients appearing under the guise of medicaments. Conceivably, the problem of nutrition might

[61] See Taylor, "Why Enrichment of Flour?" pp. 77-108; J. S. Davis, *Vitamin Enrichment and Fortification of Foods,* Contribution 110 (Food Research Institute, Stanford University, 1941), and "World Wheat Survey and Outlook, May 1942," *Wheat Studies,* Vol. XVIII, pp. 352-54. The following information is taken from the last two of these sources. On October 1, 1941, the Committee on Food and Nutrition of the National Research Council recommended "appropriate enrichment of flour and bread (and perhaps corn meal), the fortification of milk with vitamin D, the suitable addition of vitamin A to table fats and of iodine to salt for dietary use. There is no information available to the Committee at the present time which indicates that it will be desirable to recommend the addition of vitamins and minerals to foods other than those named." The Committee "opposes the addition of synthetic vitamins to carbonated beverages and confectionery." The opposition of the Committee to general and indiscriminate enrichment or fortification of foods is based upon the following grounds: (1) in many cases the necessary technical methods have not been developed; (2) fortification would often be transitory because of losses in cooking; (3) the necessary supplies of specific vitamins are needed for more urgent uses, including enrichment or fortification programs already endorsed; (4) consumers already tend to eat too much of, or to spend too much on, the products in question, to the detriment of their diets; and (5) there is a possibility of creating a vitamin or mineral imbalance (about this little is known at present). On May 27, 1941 the Food and Drug Administration proposed standards for the mandatory enrichment of flour with thiamin, riboflavin, nicotinic acid and iron; and its optional enrichment with, in addition, calcium, vitamin D and wheat germ. Except in the case of riboflavin, supplies of these nutrients have proved readily available, and the flour enrichment program is well under way: bakery sales of enriched bread rose from something like 35 percent of the total late in 1941 to over 50 percent by May 1, 1942. Continued insufficiency of supplies of riboflavin has forced postponement of the date when the Food and Drug Administration program of enrichment is to become mandatory until April 20, 1943. The Administration has also announced standards for the fortification of evaporated milk with vitamin D and of oleomargarine with vitamin A. In 1941 about half the oleomargarine sold was so fortified.

be resolved in the chemical works rather than on the farm. But the increased consumption of such commercial preparations is unlikely to settle the question of a balanced diet for the population in general for two reasons. First, the vitamins and minerals whose physiological requirements are known, and which are commercially available, are believed to represent only a few out of an unknown number of such substances. A diversified diet is likely to supply a much wider range of needed elements than can possibly be obtained at the drug store. Second, since the consumption of manufactured vitamin and mineral preparations tends to be regarded as a form of medication, it is likely, at least in the case of adults, to be sporadic at best and to be resisted by those in apparent good health.[62]

In what directions, then, is progress to be sought? We may assume that the nutritional education of the public at large, through the teaching of home economics or otherwise, will play a larger part in the future than it seems to have played in the past. But whether or not education expands in influence, rising per capita real income seems certain to push food habits somewhat further in directions very similar to those which the nutritional scientist would recommend. The consequences for agriculture would appear to be a continuation of the trend away from cereals and potatoes (and possibly even away from livestock meat products) toward dairy products and fruits and vegetables.

That large changes are still to come may be guessed from the great differences at present observable between the diets of the poor and the diets of the well-to-do. It seems certain that rising standards of living will assimilate the former to

[62] The Committee on Food and Nutrition of the National Research Council "strongly favors the policy of seeing to it that ordinary staple foods will provide a nutritionally adequate diet, reserving administration of synthetic vitamins and vitamin concentrates as such for individual cases under competent medical advice" (Davis, *Vitamin Enrichment and Fortification of Foods*, p. 3). Moreover, the Committee opposes the indiscriminate enrichment or fortification of foods with synthetic vitamins (see footnote 61).

the latter, even if no alteration occurs in the distribution of income. Moreover, the science of nutrition is still young. It may be taken as symptomatic of the continued hold that the old energy concept of nutrition has had upon us until recently that in 1926 Working was still comparing sugar and flour on the economic basis used by Atwater, i.e., cost per unit of energy. True, refined flour is anything but rich in minerals and vitamins, yet there can be little doubt that sugar is a poor substitute, whenever the merits of the two are compared without regard to the balance of other food items consumed with them. It is the energy concept, too, that has served us in the past as a gauge with which to classify foods as "cheap" and "expensive." Thus Working states, "the diversified diet is distinctly more expensive than was the staple diet it has supplanted." [63] This is no doubt sound, if we think in terms of cost per calorie. Whether it is true, too, if we think in terms of cost per unit of vitamin, or per gram of calcium or iron, is at least doubtful. However, it is safe to assume that this heritage from bygone days will stay with us as long as a sizable proportion of our population has to reckon in terms of calories first and almost exclusively—that is, as long as the need to satisfy the "hollow" hunger at the least cost leaves no room for consideration of the "hidden" hunger. In this respect there are definite limits to the effects of nutritional education.

[63] "The Decline in the Per Capita Consumption of Flour in the United States," p. 287.