ESSENTIALS *of* NUTRITION

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by Henry C. Sherman
and Caroline Sherman Lanford
Columbia University

SECOND EDITION

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PREFACE

The purpose of this book is to offer its readers a thoroughly adequate and up-to-date view of the essentials of nutrition. We hope that it will be found useful both to those who do and those who do not expect to proceed later to a more detailed, professional study of nutrition and dietetics.

The present text assumes no prerequisite training in science. Special care has therefore been given to the mode of dealing with such terms as nutrition uses in common with other sciences, and such as are just now in course of becoming everyday words. Recognizing that the effectiveness of the text depends largely upon freedom from interruption by formal definitions, we have sought rather to introduce each scientific term only as its employment becomes clearly useful, and then functionally. For cases in which more dictionary-like definitions may also be useful a glossary is provided in Appendix G.

It is realized that at present the teaching of nutrition, like the scientific subject matter itself, is in a rapidly developing stage. It is hoped that this text will contribute to this development, and that its use will enable the teacher more readily to meet the demands of the growth of fundamental scientific knowledge of nutrition within the time-limits of the non-technical course.

The present approach to the facts and principles of the science of nutrition is mainly through the relations of food to health and efficiency. Chief prominence is given to the case of the normal young person such as the majority of the

readers of this book will presumably be; though the concluding chapters take up also the problems of food for family groups, and of making nutritional knowledge more widely effective. Most of the Exercises at the ends of the chapters are, like the text itself, put in terms of the student's own experience and objectives. The Exercises and Suggested Readings are to be regarded as entirely optional. In many courses, no doubt, actual laboratory work will be provided instead. One of our main objects is to provide a textbook which leaves the teacher entirely free to design the accompanying laboratory work, or collateral reading, or both, in accordance with the circumstances and purposes of the particular course. The sequence of topics is also readily adjustable.

The subject matter of the text begins with an introductory chapter which is intended to indicate both the position of the present-day science of nutrition and its constructive aims. For many, such an advance indication of the far-reaching significance of our newest knowledge of nutrition increases the interest and effectiveness of the study. Those, however, who prefer to omit or postpone such evaluation will find it entirely feasible to make a logical beginning with the second or even with the third or fourth chapter.

Then follows the central body of the topical subject matter, treated in the order which most teachers prefer: (1) the energy aspects of nutrition, (2) the proteins and their amino acids, (3) the mineral elements, and (4) the vitamins.

This is generally found the most satisfactorily teachable sequence from the viewpoint of the interrelationships of the topics. It has also another important advantage. To a noteworthy extent it corresponds with the chronological sequence in which the main aspects of the present-day science of nutrition have developed. Thus we study first the parts of our subject which have had longest in which to take definite shape and which can therefore be presented most simply and concisely. After this we are better prepared for the somewhat more detailed treatment which the newer subject matter of

the vitamins requires if its study is to be of equal scientific soundness. Some of the most recent advances of knowledge in the vitamin field are so important, in the light which they throw upon everyday nutritional problems, that the somewhat fuller mode of exposition here finds a practical reward as well as a teaching reason.

The chapters on vitamins are so written that they may be studied in any sequence desired. The order followed in this text is the one which to us seems, in the present state of knowledge, best adapted to effective teaching. As a further aid to interest, the arrangement within each chapter is determined by the merits of its own subject matter in preference to the rigid following of a fixed form. If desired, chapters XIV and XVII may be omitted without loss to the understanding of the other chapters.

The last four chapters are extensions of nutrition study into broader fields. Any of them can be omitted, without impairing the scientific coherence of the body of the book, when adaptation to a shorter course is desired or the teacher prefers to develop some other line of application.

The tables in the body of the text are kept short for comfortable reading. Data of food values thus used, to illustrate or to amplify some particular chapter, are taken as typical from among the much more numerous data tabulated in the Appendix. These tabulations, and particularly the quantitative data for vitamin values of foods, represent the results of a very extended and painstaking study of all the evidence available to the authors up to the end of February 1940.

For the privilege of using unpublished data in drawing our deductions, for the use of illustrative materials, and for guidance in other ways, we are indebted to many scientific friends among whom certainly specific acknowledgment is due to Drs. E. L. Batchelder, F. G. Benedict, L. E. Booher, C. A. Browne, H. L. Campbell, T. M. Carpenter, E. F. DuBois, Martha Eliot, C. J. Farmer, E. C. Kendall, C. G. King, H. E. Munsell, John B. Nichols, and M. S. Rose.

ADDITIONAL PREFACE TO SECOND EDITION

In offering this new edition, the authors desire to express their high appreciation both to the users of the book for the gratifying reception accorded to it, and to the publishers for making possible so early an opportunity to incorporate the most recent advances in the science of nutrition and in the movement to make this science ever more effective in the service of health and efficiency.

While the general character and scope are much the same as in the first edition, each chapter has been carefully revised with the double objective of bringing it thoroughly up to date, and of improving the clarity and conciseness of the text wherever possible. Fortunately the most recent advances have at several points made the evidence clearer so that it has been possible to add the new facts and at the same time to simplify the forms of statement. Substances newly found to be essential to human nutrition are introduced in Chapter XIV. Important new features in what is now commonly called our national nutrition program are outlined in Chapters I, XX, and XXI. Many of the other chapters also have been largely rewritten to incorporate qualitatively new discoveries and to revise quantitative estimates of needs and "dietary standards" in accordance with the *Recommended Daily Allowances for Specific Nutrients* published by the National Research Council and often called "the new yardstick of good nutrition."

CONTENTS

ESSENTIALS of NUTRITION

Chapter I

THE NUTRITIONAL IMPROVEMENT OF LIFE

Students now enter American colleges taller and yet younger than were their parents and other predecessors when they entered the same colleges thirty years ago. This is shown consistently by all the available records, and is true of both boys and girls. There has not been any known change in proportions of racial stocks which could account for the differences. The explanation is to be found not in inheritance in the biological sense but in a social inheritance,—the increase of scientific knowledge and its use in the betterment of conditions of living.

Prominent among the advances in knowledge of life and health and resulting improvement of ways of living has been the development of the science of nutrition and its influence upon the daily choice and use of food.

A generation ago, all the more abundant constituents of food were sufficiently known to chemists so that one might analyze a food with as much accuracy as a rock or a soil, yet one could not successfully nourish himself or an experimental animal with a mixture of the food constituents which analysis revealed.

Professor (now Sir) Frederick Gowland Hopkins of Cambridge University reported briefly in 1906 and fully in 1912 his experiments which made clear to students of normal nutrition that there must exist in certain foods some substance or substances not previously known, but essential to the nutritional process. He showed that laboratory animals soon ceased to thrive on mixtures of purified proteins, fats,

carbohydrates, and salts even when these were selected and proportioned in the light of all available knowledge; but that the addition of a small amount of milk, fresh or dried, or of the alcohol-extract of dried milk or of certain vegetables (but not the ashes of such foods or extracts) made the diet adequate. Figures 1 and 2 show graphically the results of typical experiments. Those experiments showed that some unidentified alcohol-soluble organic substance or substances must function in normal nutrition. We now know that there are several such substances, some soluble in water and others in fat. Individually, they will be studied in Chapters XI-XVII. In the present discussion we are concerned with the general relation of this discovery and its sequel to the significance of nutrition as a factor in our understanding of nature and in the scientific management of our own lives.

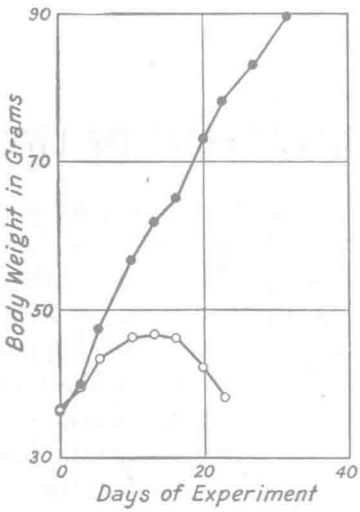

FIG. 1. Growth curves of rats in early experiments of Sir Frederick Gowland Hopkins. The lower curve represents the average body weight of a group of rats after varying intervals on an artificial diet of highly purified foodstuffs. The upper curve shows the growth of an initially similar group of rats receiving 2 cc. of milk each per day in addition to the artificial diet. (*Courtesy of Sir F. Gowland Hopkins.*)

For the discovery of these substances,—tentatively called vitamins and beginning to be known by more distinctive individual names,—has proven to be only the first step in a very far-reaching scientific development of great importance to the improvement of life.

Modern science constantly strives to make itself more and more exact. So as soon as the existence of "vitamins" was discovered, even without waiting for their complete chemical identification, studies were begun upon such quantitative questions as: (1) the relative abundance of a given vitamin in different kinds of food; (2) the amounts needed in nutri-

tion; and (3) the more ambitious question, how much of each gives the *best* results, *i.e.*, what is the level of *optimal* as distinguished from merely adequate *nutritional intake.*

Our present-day realization of the importance of this latter problem is a development of much greater significance than is yet generally understood.

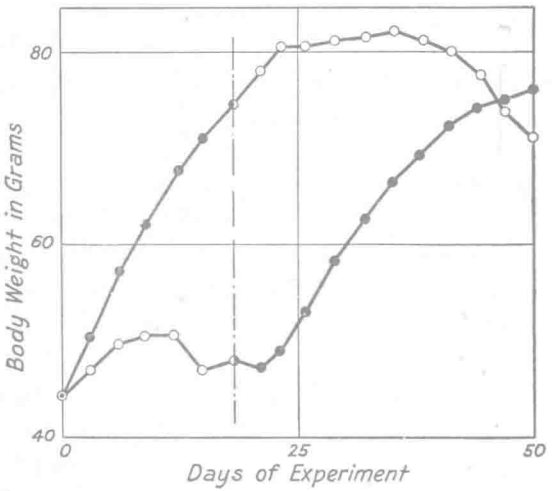

FIG. 2. Growth curves of rats in early experiments of Sir Frederick Gowland Hopkins. The lower curve represents the growth of rats receiving (up to the 18th day of the experiment) only the purified diet; the upper curve, similar rats having (up to the 18th day) 3 cc. of milk each per day in addition to this food. From the 18th day of the experiment, marked by the vertical dotted line, the milk was transferred from the latter set of animals to the former. (*Courtesy of Sir F. Gowland Hopkins.*)

While this fact was revealed largely through experiments which grew out of the investigation of the newly-discovered vitamins, it is equally true of some of the mineral elements which have long been recognized as essential to nutrition but whose far-reaching potentialities have but recently been brought fully to light. (For example, the work with different levels of calcium intake, noted in Chapter VIII.)

The rapid sequence of such discoveries has been in great measure due to the increasing use of laboratory animals as

instruments and reagents of nutritional research. By use of a species whose nutritional chemistry is closely similar to ours (with respect to the substances under investigation) and which runs much more rapidly than we do through its growth and development and the subsequent events of its life history, science can now study the relations between food intake, nutritional responses, and resulting health, much more comprehensively than had previously been possible.

For about twenty years McCollum has taught that there may be important differences between the merely adequate and the optimal in nutrition. And J. F. Williams, in his teaching of personal hygiene, has emphasized that health may and should mean not merely freedom from disease but rather a positive quality of life, and that there are degrees of this positive health; though he remarked that for some years this view only slowly found wide acceptance. That acceptance of this view of health is now rapidly spreading, or, as the *Journal of the American Medical Association* has editorially phrased it, "that the difference between buoyant health and merely passable health is coming to be more appreciated," is doubtless largely due to the objective and quantitative nature of present-day nutritional research. For this gives to its findings an impersonal convincingness which advances the principle of the nutritional improvability of the normal out of the realm of opinion into that of established physiological fact. Such nutritional improvement of already-normal health has been shown at every stage of the life cycle with statistical convincingness and conclusiveness of a very much higher order than science considers necessary to establish a physiological fact as "undoubted."

Thus notwithstanding individual (physiological) variability, the well-controlled colony of experimental animals, from which large numbers of strictly comparable individuals of known hereditary and nutritional antecedents can be drawn, becomes an instrument of research such as has never existed before. By the use of this instrument, higher precision and deeper insight both become possible, and these in turn are revealing an essentially new concept of the influence of nutrition.

To make this clear and definite, let us glance at some recent and current work at Columbia University where there is maintained for research of this kind a colony of laboratory-bred experimental rats in which the hereditary and nutritional background of each individual is known for so many generations as to correspond with a human population whose food supply had been known, whose blood had been unmixed, and whose family trees could be traced in all their branches, for well over 1000 years. With such a colony to draw upon, strictly parallel test groups can be placed simultaneously upon the different dietaries which it is desired to compare.

In all such controlled research, we plan to introduce only one variable at a time. In nutritional problems of the sort which we are considering, the experimental variables are of two kinds: (1) individual chemical factors, elements or compounds as the case may be; and (2) the actual articles of food which nature and agriculture produce and which people obtain and consume.

In a case of the latter type, a certain basal *Diet A* showed itself adequate under the severe test of maintaining fully normal health with successful reproduction and rearing of young, generation after generation; yet when the proportion of milk in this food supply was doubled the resulting *Diet B* was better in that it induced a more buoyant health, or built the already-normal health to a higher level.

Whether at this higher level the actual optimum has been reached, or whether that is higher still, remains to be determined; but the measured differences in well-being, between the adequately nourished families on Diet A and their cousins who received the more scientifically balanced Diet B, show clearly and conclusively that our knowledge of nutrition has now entered a new era in which it can (and doubtless will) play a larger part in the attainment of a higher general level of health and efficiency than had previously been thought possible.

In the investigation just mentioned, the only experimental variable was the proportion in which the natural foods entered into the diet; but the increased proportion of milk when

translated into chemical terms meant major enrichments of the diet in the three chemical factors calcium, vitamin A, and riboflavin which we shall study individually in Chapters VIII, XIII, and XV. New series of experiments were therefore begun in which each of these nutrients was studied independently and at successively increased levels of intake.

Here it is being found that calcium, vitamin A, and riboflavin each is capable of conferring successively increased benefit at successively higher levels of intake through an unexpectedly wide range. Hitherto, it has been the accepted view (sometimes even expounded as a fundamental economic principle) that one cannot advantageously consume much more food than one actually needs; in other words that, in the case of food, the level of minimal adequacy is very nearly the optimal level of consumption. This now proves to have been an oversimplified view. A more discriminating statement is needed. Of total food as measured in calories a very small surplus above actual need *does* suffice to bring us to the optimal level of intake of *this* nutritional factor. And probably of many other factors the optimal level is only moderately higher than that of minimal adequacy, perhaps around fifty per cent higher as is commonly assumed for protein and for phosphorus in the teaching of dietetics. But for *some* factors we now find that the beneficial margins are much higher than this.

This finding, with its consequences which we shall later study more fully, has such far-reaching significance that some have inclined to call it "a new principle of liberality in dietetics"; but it should not be confused with a merely open-handed attitude. The *principle* is one of *scientific discrimination*. What is true of calcium is *not* to be assumed to be true of other mineral elements; and what is true of vitamin A and riboflavin is not to be assumed to be true for other vitamins (though it may be for some of them). The three factors here discussed were not taken at random for the investigation above mentioned. They were investigated because the results of a previous investigation pointed directly and specifically to them as probable keys to the fuller under-