

CRC

HANDBOOK SERIES
in
NUTRITION
and
FOOD

M. RECHCIGL, JR.

**SECTION E:
NUTRITIONAL DISORDERS
VOLUME II**

CRC

PRESS

CRC Handbook Series in Nutrition and Food

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Nutrition Advisor and Director
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Section E: Nutritional Disorders

Volume II

**Effect of Nutrient Deficiencies
in Animals**



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CRC HANDBOOK SERIES IN NUTRITION AND FOOD

Miloslav Rechcigl, Jr.

Editor-in-Chief

SECTION OUTLINE

SECTION A: **Science of Nutrition and Food**

Nomenclature, Nutrition Literature, Organization of Research, Training and Extension in Nutrition and Food, Nutrition Societies, and Historical Milestones in Nutrition.

SECTION B. **Part 1: Ecological Aspects of Nutrition**

The Living Organisms, Their Distribution and Chemical Constitution, Habitats and Their Ecology, Biotic Associations and Interactions, Cycling of Water in the Biosphere, Ecosystem Productivity, and Factors Affecting Productivity of Animals and Plants.

SECTION B. **Part 2: Physiological Aspects of Nutrition**

Feeding and Digestive Systems in Various Organisms, Food Assimilation Processes in Microorganisms and Plants, Selection of Food in Various Organisms, Factors Affecting Food and Water Intake, Gastrointestinal Tract-Anatomical, Morphological and Functional Aspects, Passage of Ingesta in Various Organisms, Digestive Enzymes, Nutrient Absorption, Transport, and Excretion, Cellular Digestion and Metabolism.

SECTION C: **The Nutrients and Their Metabolism**

Chemistry and Physiology of Nutrients and Growth Regulators, Antinutrients and Antimetabolites, Nutrient Metabolism in Different Organisms, Regulatory Aspects of Nutrient Metabolism, Nutritional Adaptation, Biogenesis of Specific Nutrients, and Nutrient Interrelationships.

SECTION D: **Nutritional Requirements**

Comparative Nutrient Requirements, Qualitative Requirements of Specific Organisms, Tissues, and Cells, Quantitative Requirements (Nutritional Standards) of Selected Organisms, Nutritional Requirements for Specific Processes and Functions, and Requirements and Utilization of Specific Nutrients.

SECTION E: **Nutritional Disorders**

Nutritional Disorders in Specific Organisms, Nutritional Disorders in Specific Tissues, Effect of Specific Nutrient Deficiencies and Toxicities (3 Vol.), and Nutritional Aspects of Disease.

SECTION F: **Food Composition, Digestibility, and Biological Value**

Nutrient Content and Energy Value of Foods and Feeds, Factors Affecting Nutrient Composition of Plants, Factors Affecting Nutrient Composition of Animals, Effect of Processing on Nutrient Content of Foods and Feeds, and Utilization and Biological Value of Food.

SECTION G: **Diets, Culture Media, and Food Supplements**

Diets for Animals, Diets for Invertebrates, Culture Media for Microorganisms and Plants, Culture Media for Cells, Organisms and Embryos, and Nutritional Supplements.

SECTION H: **The State of World Food and Nutrition**

World Population, Natural and Food Resources, Food Production, Food Losses, Food Usage and Consumption, Socioeconomic, Cultural, and Psychological Factors Affecting Nutrition, Geographical Distribution of Nutritional Diseases, Nutrient Needs - Current and Projected, Agricultural Inputs - Current and Projected, Food Aid, and Food Marketing and Distribution.

SECTION I: **Food Safety, Food Spoilage, Food Wastes, Food Preservation, and Food Regulation**

Naturally Occurring Food Toxicants, Food Contaminants, Food Additives, Food Spoilage and Deterioration, Disposal of Food Wastes, Food-Borne Diseases, Detoxication of Foreign Chemicals, Food Sanitation and Preservation, Food Laws, and Nutrition Labeling.

SECTION J: **Production, Utilization, and Nutritive Value of Foods**

Plant and Animal Sources.

SECTION K: **Nutrition and Food Methodology**

Assessment of Nutritional Status of Organisms, and Measuring Nutritive Value of Food.

PUBLISHER'S PREFACE

In 1913, when the First Edition of the *Handbook of Chemistry and Physics* appeared, scientific progress, particularly in chemistry and physics, had produced an extensive literature but its utility was seriously handicapped because it was fragmented and unorganized. The simple but invaluable contribution of the *Handbook of Chemistry and Physics* was to provide a systematic compilation of the most useful and reliable scientific data within the covers of a single volume. Referred to as the "bible," the Handbook soon became a universal and essential reference source for the scientific community. The latest edition represents more than 65 years of continuous service to millions of professional scientists and students throughout the world.

In the years following World War II, scientific information expanded at an explosive rate due to the tremendous growth of research facilities and sophisticated analytical instrumentation. The single-volume Handbook concept, although providing a high level of convenience, was not adequate for the reference requirements of many of the newer scientific disciplines. Due to the sheer quantity of useful and reliable data being generated, it was no longer feasible or desirable to select only that information which could be contained in a single volume and arbitrarily to reject the remainder. **Comprehensiveness** had become as essential as **convenience**.

By the late 1960's, it was apparent that the solution to the problem was the development of the multi-volume Handbook. This answer arose out of necessity during the editorial processing of the *Handbook of Environmental Control*. A hybrid discipline or, to be more precise, an interdisciplinary field such as Environmental Science could be logically structured into major subject areas. This permitted individual volumes to be developed for each major subject. The individual volumes, published either simultaneously or by some predetermined sequence, collectively became a multi-volume Handbook series.

The logic of this new approach was irrefutable and the concept was promptly accepted by both the scientist and science librarian. It became the format of a growing number of CRC Handbook Series in fields such as Materials Science, Laboratory Animal Science, and Marine Science.

Within a few years, however, it was clear that even the multi-volume Handbook concept was not sufficient. It was necessary to create an information structure more compatible with the dynamic character of scientific information, and flexible enough to accommodate continuous but unpredictable growth, regardless of quantity or direction. This became the objective of a "third generation" Handbook concept.

This latest concept utilizes each major subject within an information field as a "Section" rather than the equivalent of a single volume. Each Section, therefore, may include as many volumes as the quantity and quality of available information will justify. The structure achieves permanent flexibility because it can, in effect, expand "vertically" and "horizontally." Any section can continue to grow (vertically) in number of volumes, and new sections can be added (horizontally) as and when required by the information field itself. A key innovation which makes this massive and complex information base almost as convenient to use as a single-volume Handbook is the utilization of computer technology to produce up-dated, cumulative index volumes.

The *Handbook Series in Nutrition and Food* is a notable example of the “sectionalized, multi-volume Handbook series.” Currently underway are additional information programs based on the same organizational design. These include information fields such as Energy and Agricultural Science which are of critical importance not only to scientific progress but to the advancement of the total quality of life.

We are confident that the “third generation” CRC Handbook comprises a worthy contribution to both information science and the scientific community. We are equally certain that it does not represent the ultimate reference source. We predict that the most dramatic progress in the management of scientific information remains to be achieved.

B. J. Starkoff
President
CRC Press, Inc.

PREFACE

CRC HANDBOOK SERIES IN NUTRITION AND FOOD

Nutrition means different things to different people, and no other field of endeavor crosses the boundaries of so many different disciplines and abounds with such diverse dimensions. The growth of the field of nutrition, particularly in the last two decades, has been phenomenal, the nutritional data being scattered literally in thousands and thousands of not always accessible periodicals and monographs, many of which, furthermore, are not normally identified with nutrition.

To remedy this situation, we have undertaken an ambitious and monumental task of assembling in one publication all the critical data relevant in the field of nutrition.

The *CRC Handbook Series in Nutrition and Food* is intended to serve as a ready reference source of current information on experimental and applied human, animal, microbial, and plant nutrition presented in concise tabular, graphical, or narrative form and indexed for ease of use. It is hoped that this projected open-ended multivolume set will become for the nutritionist what the *CRC Handbook of Chemistry and Physics* has become for the chemist and physicist.

Apart from supplying specific data, the comprehensive, interdisciplinary, and comparative nature of the *CRC Handbook Series in Nutrition and Food* will provide the user with an easy overview of the state of the art, pinpointing the gaps in nutritional knowledge and providing a basis for further research. In addition, the *Handbook* will enable the researcher to analyze the data in various living systems for commonality or basic differences. On the other hand, an applied scientist or technician will be afforded the opportunity of evaluating a given problem and its solutions from the broadest possible point of view, including the aspects of agronomy, crop science, animal husbandry, aquaculture and fisheries, veterinary medicine, clinical medicine, pathology, parasitology, toxicology, pharmacology, therapeutics, dietetics, food science and technology, physiology, zoology, botany, biochemistry, developmental and cell biology, microbiology, sanitation, pest control, economics, marketing, sociology, anthropology, natural resources, ecology, environmental science, population, law, politics, nutritional and food methodology, and others.

To make more facile use of the *Handbook*, the publication has been divided into sections of one or more volumes each. In this manner the particular sections of the *Handbook* can be continuously updated by publishing additional volumes of new data as they become available.

The Editor wishes to thank the numerous contributors, many of whom have undertaken their assignment in pioneering spirit, and the Advisory Board members for their continuous counsel and cooperation. Last but not least, he wishes to express his sincere appreciation to the members of the CRC editorial and production staffs, particularly President Bernard J. Starkoff, Mr. Robert Datz, Mr. Paul R. Gottehrer, and Ms. Marsha Baker, for their encouragement and support.

We invite comments and criticism regarding format and selection of subject matter, as well as specific suggestions for new data (and additional contributors) which might be included in subsequent editions. We should also appreciate it if the readers would bring to the attention of the Editor any errors or omissions that might appear in the publication.

Miloslav Rechcigl, Jr.
Editor-in-Chief
August 1978

PREFACE
SECTION E: NUTRITIONAL DISORDERS

This section provides systematic and detailed information on all relevant aspects of the relationship between nutrition and disease. One subsection is devoted to natural and foodborne diseases in various taxa of organisms, ranging from single-cellular type to higher organisms. Another subsection concerns itself with the effect of specific nutrient deficiencies and excess, described in terms of gross, morphological, and biochemical alterations. The changes in specific tissues and organs, due to malnutrition, and the nutritional aspects of disease form the theme of the remaining subsections.

Miloslav Rechcigl, Jr.,
Editor
May 1978

MILOSLAV REHCIGL, JR., EDITOR

Miloslav Rechcigl, Jr. is Nutrition Advisor and Director of the Interregional Research Staff in the Agency for International Development, U.S. Department of State.

He has a B.S. in Biochemistry (1954), a Master of Nutritional Science degree (1955), and a Ph.D. in nutrition, biochemistry, and physiology (1958), all from Cornell University. He was formerly a Research Biochemist in the National Cancer Institute, National Institutes of Health and subsequently served as Special Assistant for Nutrition and Health in the Health Services and Mental Health Administration, U.S. Department of Health, Education, and Welfare.

Dr. Rechcigl is a member of some 30 scientific and professional societies, including being a Fellow of the American Association for the Advancement of Science, Fellow of the Washington Academy of Sciences, Fellow of the American Institute of Chemists, and Fellow of the International College of Applied Nutrition. He holds membership in the Cosmos Club, the Honorary Society of Phi Kappa Pi, and the Society of Sigma Xi, and is recipient of numerous honors, including an honorary membership certificate from the International Social Science Honor Society Delta Tau Kappa. In 1969, he was a delegate to the White House Conference on Food, Nutrition, and Health and in the last two years served as President of the District of Columbia Institute of Chemists and a Councilor of the American Institute of Chemists.

His bibliography extends over 100 publications, including contributions to books, articles in periodicals, and monographs in the fields of nutrition, biochemistry, physiology, pathology, enzymology, and molecular biology. Most recently he authored and edited *World Food Problem: A Selective Bibliography of Reviews* (CRC Press, 1975), *Man, Food, and Nutrition: Strategies and Technological Measures for Alleviating the World Food Problem* (CRC Press, 1973), *Food, Nutrition and Health: A Multidisciplinary Treatise Addressed to the Major Nutrition Problems from a World Wide Perspective* (Karger, 1973), following his earlier pioneering treatise on *Enzyme Synthesis and Degradation in Mammalian Systems* (Karger, 1971), and that on *Microbodies and Related Particles. Morphology, Biochemistry and Physiology* (Academic Press, 1969). Dr. Rechcigl also has initiated and edits a new series on Comparative Animal Nutrition and is Associated Editor of *Nutrition Reports International*.

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To my inspiring teachers at Cornell: Harold H. Williams, John K. Loosli, Richard H. Barnes, the late Clive M. McCay, and the late Leonard A. Maynard.
And to my supportive and beloved family: Eva, Jack, and Karen.

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