5th Edition

Nutrition in Pediatrics

Basic Science • Clinical Applications



Duggan • Watkins • Koletzko • Walker

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NUTRITION IN PEDIATRICS

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FIFTH EDITION

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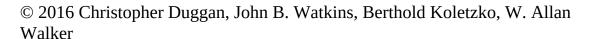
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DEDICATIONS

To the continued successful growth and nourishment of Michael, Brendan, and Emily Duggan and in gratitude for many teachers and students in the field of pediatric nutrition.

—Christopher Duggan, MD, MPH

To the children, parents, and staff of the growth and nutrition program whose shared knowledge, caring, and expertise enriches us all and to our grandchildren: Mariposa, Charlotte, Lillie, Gwen, and their "Pinkhouse" partners in "Friendship."

—John B. Watkins, MD

To a wonderful group of teachers, colleagues, and friends that I have been privileged to work with and to learn from, and to my family, especially my wife Sibylle, for all their patience and support.

—Berthold Koletzko, MD, PhD

To my youngest grandchild William McDonald Walker (Mac), the paradigm of healthy nutrition in children.

—W. Allan Walker, MD

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PREFACE

This fifth edition of *Nutrition in Pediatrics: Basic Science and Clinical Applications* is our continuing effort to establish a comprehensive and accessible approach to pediatric nutrition for a wide range of clinicians, scientists, and—most importantly—trainees. An important addition to the textbook has been the inclusion of Professor Berthold Koletzko to our Editorial Board. As Professor of Pediatrics at the University of Munich and Head of the Division of Metabolic and Nutritional Medicine at Hauner Children's Hospital, Dr. Koletzko brings a wealth of clinical and research expertise to this text. In addition, his global collaborations have allowed us to substantially broaden our team of authors, making this version of the text a truly international one.

The fifth edition builds on the foundations of the several previous versions, with updated chapters on the broad themes of General Concepts, Physiology and Pathophysiology, Perinatal Nutrition, Obesity, Nutritional Aspects of Specific Disease States, and Approach to Nutritional Support. Owing to the recognition that nutritional issues overwhelmingly affect children living in resource-poor countries, we have also added a new section entitled "Nutrition in Low- and Middle-Income Populations." Expert authors in this field have contributed reviews on the topics of the nutrition transition, complementary feeding, economic development, HIV disease, and the occurrence of obesity in developing economies.

Although all of our contributions are excellent, notable additions to this 5th edition include an outstanding leadoff chapter on the role of nutrition for health, disease prevention, and development; new contributions on macronutrients, epigenetics, and the microbiome; and several significantly revised and updated classic chapters. As in past editions, comprehensive appendices are included that serve the reader by collating important tools for nutritional assessment, nutritional requirements, and enteral products.

The editors are grateful to Ms. Linda Mehta for her many efforts in the publication of this textbook. Finally, we sincerely thank the dozens of authors who contributed countless hours of writing and research for the completion of this text. Their expertise and labors constitute the heart of this book.

—Christopher Duggan, for the editors Berthold Koletzko John B. Watkins W. Allan Walker

Nutrition: The Driving Force for Health, Disease Prevention, and Development



Robert D. Baker, MD, PhD and Susan S. Baker, MD, PhD

A SWEEPING LOOK AT NUTRITION

Nutrition is the underpinning of life itself. Good nutrition has consequences for health, societal well-being, economic stability, and advancements. Poor nutrition has a direct and measurable impact on all aspects of human functioning. Nutrition is the driving force for much of human and societal evolution. This fundamental role of nutrition has been recognized since ancient times. More recently, evolutionary biologists have recorded the importance of nutrition on evolution, and the basic requirements for the human organism have been identified.

This book deals with the scientific and clinical practice of pediatric nutrition. That it is now into its fifth edition implies that readers and users of this book are convinced of the importance of nutrition to the growing and developing child. In this first chapter, we invite "devotees" of pediatric nutrition to take a very broad look at the importance of food and to consider food as a driving force for the evolution of the human race, as a major part of our culture, as an economic force, and as a means toward future change.

From prehistory forward, food and the search for food have been

central to human evolution. In examining the expansion of humans from their African origins throughout the Middle East, Europe, Asia, the Far East including the Pacific Islands, across the bridge to North America, and south through Central America to include all of South America, one of the most striking aspects of this amazing migration is the rapidity with which it took place. After existing in Africa for 5–6 million years, the great migration started about 1 million years ago and was essentially complete about 20,000 years ago. The migration was not a single sweep, but occurred in waves and fits and starts. The reasons for man's moving were undoubtedly multifactorial, but prominent among these factors had to be food availability. The move from "gathers" to "hunter-gathers" required the acquisition of tools, weapons, and necessitated cooperation, but also ushered in conflict. The beginning of agriculture, in the fertile crescent, not only provided a more stable source of nutrition but also allowed humans to establish settlements, which required rules and patterns of behavior far different from the behavior of hunter-gathers. Among many other results of "settlements" was the possibility of specialization; most would be farmers but there were also warriors, carpenters, builders, teachers, and eventually philosophers and scientists. The move toward agriculture was gradual. Man first learned that by tending plants that bore fruit, the yield could be increased. Some tribes in New Guinea still practice this early form of agriculture. They clear completing plants from food-bearing plants and then leave returning months later to harvest the enhanced fruit production.¹ Wheat and other grains were the first food plants to be domesticated. The cultivation of pulses in addition to grains allowed both protein and carbohydrate needs to be largely supplied through plants. Domesticated animals became a readily available and dependable source of protein. Initially in the Middle East but then spreading, communities began domesticating animals; first sheep and then goats and finally cattle.

LACTOSE INTOLERANCE

About 7000–8000 years ago, these Middle Eastern farmers began consuming milk.² This created a genetic dilemma for humans. Lactose is the disaccharide in most mammalian milk, including human milk.³ Human infants, to survive, must be able to digest and use lactose. Before the introduction of dairy products into the human food chain, there was no advantage of being able to digest lactose beyond the age of weaning. So, for most of the human race, the gene that codes for lactase becomes progressively less active during childhood. However, with the introduction