

5th Edition

# Nutrition in Pediatrics

Basic Science • Clinical Applications



Duggan • Watkins • Koletzko • Walker

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# NUTRITION IN PEDIATRICS

BASIC SCIENCE • CLINICAL APPLICATIONS

## FIFTH EDITION

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# DEDICATIONS

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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

# CONTENTS

## CONTRIBUTORS PREFACE

### PART I: GENERAL CONCEPTS

#### CHAPTER 1 Nutrition: The Driving Force for Health, Disease Prevention, and Development

*Robert D. Baker and Susan S. Baker*

#### CHAPTER 2 Clinical Assessment of Nutritional Status

*Babette S. Zemel, Asim Maqbool, and Irene E. Olsen*

#### CHAPTER 3 Laboratory Assessment of Nutritional Status

*Clodagh M. Loughrey and Ian S. Young*

#### CHAPTER 4 Body Composition and Growth

*Kenneth J. Ellis*

#### CHAPTER 5 Carbohydrates

*Clemens Kunz, Lena Geiger, and Christoph Fusch*

#### CHAPTER 6 Proteins and Amino Acids

*Johannes B. van Goudoever*

#### CHAPTER 7 Macronutrient Requirements for Growth: Fats and Fatty Acids

*Kathrin Krohn, Hans Demmelmair, and Berthold Koletzko*

#### CHAPTER 8 Trace Elements

*Nancy F. Krebs and K. Michael Hambidge*

#### CHAPTER 9 Iron

*Amina Khambalia, Ashley Aimone, and Stanley H. Zlotkin*

#### CHAPTER 10 Vitamins

*Roland Kupka and Eduardo Villamor*

#### CHAPTER 11 Dietary Reference Intakes in the United States

*Alice H. Lichtenstein and Stephen R. Daniels*

#### CHAPTER 12 Functional Food Ingredients: Probiotics, Prebiotics, Nutraceuticals, and Phytochemicals

*Mandana Amir Shaghghi, Peter J.H. Jones, and Philip M. Sherman*

### PART II: PHYSIOLOGY AND PATHOPHYSIOLOGY

#### CHAPTER 13 Energy Requirements in Health and Disease

*Jean Louis Bresson*

#### CHAPTER 14 Severe Acute Malnutrition: Pathophysiology, Clinical Consequences, and Treatment

*Mary E. Penny*

#### CHAPTER 15 Childhood Malnutrition: Prevention and Control at the National Level

*Gerardo Weisstaub, Ana Maria Aguilar, Magdalena Araya, Ann Hill, and Ricardo Uauy*

#### CHAPTER 16 Community Nutrition and Its Impact on Children: Highly Industrialized Countries

*Johanna Dwyer, Kristy Hendricks, Janice H.Y. Chow, and Melanie Reyes*

#### CHAPTER 17 Nutritional Epidemiology

*Carine M. Lenders, Emily Keefe, and Walter C. Willett*

#### CHAPTER 18 Drug Therapy and the Role of Nutrition

*Kathleen M. Gura and Lingtak-Neander Chan*

### PART III: PERINATAL NUTRITION

#### CHAPTER 19 Nutrition and Gene Expression

*Mona Bajaj-Elliott and Ian R. Sanderson*

#### CHAPTER 20 Nutrition and Epigenetics

*Sang-Woon Choi and Simonetta Friso*

#### CHAPTER 21 Nutrition and the Humoral Regulation of Growth

*William E. Russell and J. Marc Rhoads*

#### CHAPTER 22 Gastrointestinal Development: Implications for Infant Feeding

*Josef Neu, Martha Douglas-Escobar, and Sandra Fucile*

#### CHAPTER 23 Diet, Environment, and Gut Microbiota in the Metagenomic Era

*Carlotta De Filippo and Paolo Lionetti*

#### CHAPTER 24 Nutrition and Neuropsychological Development

*Maureen M. Black and Kristen M. Hurley*

#### CHAPTER 25 Maternal Nutrition and Pregnancy Outcome

Theresa O. Scholl and Xinhua Chen

**CHAPTER 26 Human Growth and Disease in Later Life**

David J.P. Barker

**CHAPTER 27 Nutrition and Development of the Fetus: Carbohydrate and Lipid Metabolism**

William W. Hay, Jr., Laura D. Brown, Stephanie R. Wesolowski, and Paul J. Rozance

**CHAPTER 28 Amino Acid Nutrition in Utero: Placental Function and Metabolism**

Timothy R.H. Regnault and Frederick C. Battaglia

**CHAPTER 29 Human Milk: Nutritional Properties**

Marcia H. Monaco and Sharon M. Donovan

**CHAPTER 30 Protective Properties of Human Milk and Bacterial Colonization of the Neonatal Gut**

Anne Donnet-Hughes, Eduardo J. Schiffrin, and W. Allan Walker

**CHAPTER 31 Approach to Breastfeeding**

Robert M. Lawrence and Ruth A. Lawrence

**CHAPTER 32 The Low-Birthweight Infant: Inpatient Care**

Thibault Senterre and Alexandre Lapillonne

**CHAPTER 33 Nutritional Management of Preterm Infants Post-Discharge**

Mandy Brown Belfort

**CHAPTER 34 The Term Infant**

Ekhard E. Ziegler and Susan J. Carlson

**CHAPTER 35 Complementary Feeding and Health Outcomes**

Mary S. Fewtrell

**PART IV: OBESITY**

**CHAPTER 36 Energy and Substrate Regulation in Obesity**

Daniel J. Hoffman and Susan B. Roberts

**CHAPTER 37 Evaluation and Management of Childhood Obesity**

Alison G. Hoppin and Janey S. Pratt

**CHAPTER 38 The Metabolic Syndrome in Children and Adolescents**

Martin Wabitsch

**CHAPTER 39 Childhood Obesity Prevention**

John J. Reilly and Adrienne H. Hughes

**PART V: NUTRITION IN LOW- AND MIDDLE-INCOME COUNTRIES**

**CHAPTER 40 The Nutrition Transition and Global Child Health**

Benjamin Caballero

**CHAPTER 41 Infant and Young Child Feeding in Low- and Middle-Income Countries**

Souheila Abbeddou and Kenneth H. Brown

**CHAPTER 42 Child Nutrition and Economic Development**

William A. Masters

**CHAPTER 43 Global Interventions in Child Health**

Zulfiqar Ahmed Bhutta and Jai K. Das

**CHAPTER 44 Pediatric HIV Infection**

Colleen Hadigan and Anna Coutsoudis

**CHAPTER 45 Obesity in Developing Economies**

Sumathi Swaminathan and Anura Kurpad

**PART VI: NUTRITIONAL ASPECTS OF SPECIFIC DISEASE STATES**

**CHAPTER 46 Feeding Difficulties**

Peter B. Sullivan

**CHAPTER 47 Failure-to-Thrive: Growth Failure in the Outpatient Setting**

Jennifer A. Woo Baidal and Susanna Y. Huh

**CHAPTER 48 Developmental Disabilities**

Kelly A. Dougherty and Babette S. Zemel

**CHAPTER 49 Inborn Errors of Metabolism and the Liver**

Charles P. Venditti and Gerard T. Berry

**CHAPTER 50 Inborn Errors of Fasting Adaptation—Glycogen Storage Disease**

David A. Weinstein and Katalin M. Ross

**CHAPTER 51 Acute and Chronic Kidney Disease: Nutrition in Renal Disease**

Nancy M. Rodig

**CHAPTER 52 Inflammatory Bowel Disease**

Francesca Penagini and Rob Heuschkel

**CHAPTER 53 Celiac Disease**

Dascha C. Weir and Ciaran P. Kelly

**CHAPTER 54 Food Allergies**

*Julie Wang, Jennifer M. Maloney, and Hugh A. Sampson*

**CHAPTER 55 Exocrine Pancreas**

*Kevin Gaskin and Karen Blumenthal*

**CHAPTER 56 Acute and Chronic Liver Disease**

*Deirdre A. Kelly, Susan Protheroe, and Sara Clarke*

**CHAPTER 57 Cancer Prevention**

*A. Lindsay Frazier*

**CHAPTER 58 Cancer Treatment**

*Lori J. Bechard and Christopher Duggan*

**CHAPTER 59 Diabetes Mellitus**

*Joseph I. Wolfson, Sanjeev Mehta, Maryanne Quinn, and Karen Y. Warman*

**CHAPTER 60 Diarrheal Diseases**

*Kerri Gosselin and Christopher Duggan*

**CHAPTER 61 Intestinal Failure, Short Bowel Syndrome, and Intestinal Transplantation**

*Daniel Kamin*

**CHAPTER 62 The Critically Ill Child**

*Eric A. Sparks, Jeremy G. Fisher, Faraz A. Khan, Nilesh M. Mehta, and Tom Jaksic*

**CHAPTER 63 Hyperlipidemia and Cardiovascular Disease**

*Sarah D. de Ferranti*

**CHAPTER 64 Diet and Dental Disease**

*Rosalyn Sulyanto and James H. Shaw*

**CHAPTER 65 Adolescent Eating Disorders**

*Kendrin R. Sonnevile and Alison E. Field*

**CHAPTER 66 Adolescence: Advancing Bone Health**

*Keith J. Loud and Catherine M. Gordon*

**PART VII: APPROACH TO NUTRITIONAL SUPPORT**

**CHAPTER 67 Enteral Nutrition and Formulas**

*Zoë McCallum and Julie E. Bines*

**CHAPTER 68 Parenteral Nutrition**

*Corina Hartman, Arie Riskin, and Raanan Shamir*

**CHAPTER 69 Nutrition in the Athlete**

*Kathryn E. Ackerman and Madhusmita Misra*

**CHAPTER 70 Special Diets**

*Sharon Evans, Tracey Johnson, Katharina Dokoupil, and Anita MacDonald*

**CHAPTER 71 Nutrition Support Teams**

*Virginie Colomb and Cécile Lambe*

**APPENDICES**

**APPENDIX I Nutritional Assessment**

*Melanie V. Connolly*

**APPENDIX II Nutritional Requirements**

*Melanie V. Connolly*

**APPENDIX III Enteral Products**

*Melanie V. Connolly*

**INDEX**

# CONTRIBUTORS

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*Infant and Young Child Feeding in Low- and Middle-Income Countries (41)*

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*Nutrition in the Athlete (69)*

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*Iron (9)*

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Setting (47)*

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*Nutrition and Gene Expression (19)*

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*Nutrition: The Driving Force for Health, Disease Prevention, and Development (1)*

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*The Term Infant (34)*

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*Acute and Chronic Liver Disease: Nutrition in Renal Disease (56)*

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*Appendix I: Nutritional Assessment*  
*Appendix II: Nutritional Requirements*  
*Appendix III: Enteral Products*

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*Special Diets (70)*

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*Protective Properties of Human Milk and Bacterial Colonization of the Neonatal Gut (30)*

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*Human Milk: Nutritional Properties (29)*

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*Diarrheal Diseases (60)*

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*Community Nutrition and Its Impact on Children: Highly Industrialized Countries (16)*

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*Body Composition and Growth (4)*

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*Special Diets (70)*

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*Complementary Feeding and Health Outcomes (35)*

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*Adolescent Eating Disorders (65)*

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*The Critically Ill Child (62)*

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*Cancer Prevention (57)*

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*Nutrition and Epigenetics (20)*

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*Gastrointestinal Development: Implications for Infant Feeding (22)*

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*Carbohydrates (5)*

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*Exocrine Pancreas (55)*

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*Carbohydrates (5)*

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*Adolescence: Advancing Bone Health (66)*

**Kerri Gosselin, MD**

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*Diarrheal Diseases (60)*

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*Proteins and Amino Acids (6)*

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*Drug Therapy and the Role of Nutrition (18)*

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*Childhood Malnutrition: Prevention and Control at the National Level (15)*

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*Failure-to-Thrive: Growth Failure in the Outpatient Setting (47)*

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*Iron (9)*

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*Obesity in Developing Economies (45)*

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*Nutrition Support Teams (71)*

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*Approach to Breastfeeding (31)*

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*Dietary Reference Intakes in the United States (11)*

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*Diet, Environment, and Gut Microbiota in the Metagenomic Era (23)*

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*Child Nutrition and Economic Development (42)*

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*Enteral Nutrition and Formulas (67)*

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*Nutrition in the Athlete (69)*

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*Human Milk: Nutritional Properties (29)*

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*Gastrointestinal Development: Implications for Infant Feeding (22)*

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*Severe Acute Malnutrition: Pathophysiology, Clinical Consequences, and Treatment (14)*

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*Protective Properties of Human Milk and Bacterial Colonization of the Neonatal Gut (30)*

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*Inborn Errors of Metabolism and the Liver (49)*

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Vitamins (10)

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*Developmental Disabilities (48)*

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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

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**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.<sup>1</sup> 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 “gatherers” to “hunter-gatherers” 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-gatherers. 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.<sup>1</sup> 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.<sup>1</sup> 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.<sup>2</sup> This created a genetic dilemma for humans. Lactose is the disaccharide in most mammalian milk, including human milk.<sup>3</sup> 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