Contents

Anatomical Gut Growth and Development ............................. 1
Jacques Schmitz

Digestive Functions and Their Hormonal Regulation During
Perinatal Development in Man and Experimental Animals .......... 9
Otakar Koldovský

Gut Development and Immunology ................................. 23
Thomas T. MacDonald

The Evolution of Research Techniques in Premature Infant
Nutrition ................................................................. 31
Buford L. Nichols, Jr.

Fluid Requirements, Water Balance, and Metabolism in Low
Birthweight Infants .................................................. 43
Jean-Léopold Micheli, Yves Schutz, Riccardo Pfister,
Bernard Laubscher, André Calame, and Eric Jéquier

Thermoregulation and Environmental Influences on Energy
Expenditure of the Low Birthweight Infant ......................... 61
Eric Jéquier

Utilization and Storage of Energy .................................. 71
Guy Putet, Jean-C. Picaud, Bernard L. Salle, Jacques Rigo, and
Jacques Senterre

Fat Digestion: Intestinal Lipolysis and Product Absorption ........ 83
Lars Bläckberg and Olle Hernell

Requirements of Preterm Infants for Long-Chain Polyunsaturated
Fatty Acids: Experimental Study with Placenta Phospholipids .... 93
Véronique Chirouze

Modification of Protein Metabolism Due to Disease ............. 105
Naomi K. Fukagawa
CONTENTS

Placental Transfer of Minerals .......................................................... 115
R. D. H. Boyd, S. Byrne, D. Edwards, J. Glazier, S. Greenwood,
S. Husain, D. Mahendran, Z. Mughal, J. Štulc, and C. Sibley

Calcium, Phosphorus, Magnesium, and Vitamin D Requirements in
Premature Infants ................................................................. 125
Bernard L. Salle, Jacques Senterre, and Guy Putet

Transport of the Lipid Soluble Vitamins A, D, and K by Human
Placenta ........................................................................... 137
Edgard E. Delvin

Vitamins for Very Low Birthweight Infants ................................. 153
Marcello Orzalesi and Renato Lucchini

Nutrition, Growth, and Body Composition .............................. 169
William C. Heird, Sudha Kashyap, Rajasekhar Ramakrishnan,
Karl F. Schulze, and Ralph B. Dell

Influence of Neonatal Nutrition on Long-Term Outcome ........ 183
Alan Lucas

An Approach to Partial Parenteral Nutrition in Extremely Low
Birthweight Infants ............................................................. 197
Antonio Priolisi

Concluding Remarks ............................................................... 211
Bernard L. Salle

Subject Index ....................................................................... 213
Preface

The main goal for nutrition of the low birthweight infant is to provide sufficient nutrients to fulfill the infant's genetic potential (1). Unfortunately, we have no way of assessing genetic potential at this early and premature stage of development. We resort to indirect and average standards from population studies of growth and development, nutrient balance and accretion, energy metabolism and body composition. But there is no guarantee that such averages will necessarily fit the individual. The distinction between intrauterine growth restriction (IUGR) and small for gestational age (SGA) (i.e., small but normal for the individual), needs to be made.

The mention of genetic potential brings to mind one of the most intriguing unsolved problems in nutrition which pertains to the old argument of the relative influences of nature and nurture. To what extent does genetics determine body composition and development, and how much can these be influenced by nutrition? Or, more colloquially, are we really what we eat? You are all familiar with Widdowson and McCance's concept of sensitive epochs in early development when periods of deprivation lead to permanent defects which may not be subsequently repaired (2). Dobbing and co-workers have shown this to be particularly true for the brain (3). Are these sensitive periods important to the setting of appetite as well as growth? And would such appetite settings control body composition in later life?

These concepts and questions are particularly relevant to the premature, low birthweight infant in the perinatal period for two reasons. First, this epoch comprises the period of most rapid growth of the whole lifespan. Second, the infant may be doubly deprived—prenatally from inadequate placental transfer, and postnatally because nutrient input may be compromised, not only (a) by technical difficulties of enteral or parenteral feeding and immature mechanisms for nutrient processing, but also (b) by the relative inability of the physician to shape the nutrient input to the infant's needs, at least until, and if, the infant can satisfactorily be established on the breast and consequently exercise some control by means of appetite. Until this occurs the physician effectively has absolute control of both the volume and the content of nutrient intake and, short of rejection by persistent vomiting, the infant is a passive recipient for all that is poured into his/her stomach or vein. Although the dangers of undernutrition are well recognized, oversupply may also have its perils. For example, the hypercalcemic syndromes experienced in the United Kingdom during and after World War II because of the overenthusiastic supply of vitamin D in fortified foods, as well as the azotemia, acidemia and distorted blood amino acid patterns resulting from the use of high protein milk formulas in the 1950s.

There is also the problem of infant and childhood obesity. The twins studies of Stunkard et al. appear to suggest that genetics has the greater role to play in the
causation of obesity in later life (4), but it is a common experience that environmental influences on feeding patterns and energy expenditure also operate.

The steady increase in average bodily stature experienced in many jurisdictions in recent years has generally been ascribed to improved nutrition with enhanced socioeconomic circumstances permitting better fulfillment of the genetic potential for growth. Is there an optimal limit, an upper limit? Are they necessarily identical? To what extent is the perinatal period nutritionally influential on the subsequent growth and development of the low birthweight infant? It has been reported that at least 30% of such infants are below the 5th percentile at 2 years of age (6).

In the future, will geneticists and molecular biologists be able to identify the genetic codes for growth and body composition? What are the limiting factors, other than supply, for micronutrient, nitrogen, and energy accretion? Is there a genetic delimitation of the lower, optimal, and upper limits of intake of each individual nutrient by the genetically-determined mechanisms for their handling? Does the optimal necessarily correspond with the upper limit of intake? What are the hormonal levers for growth and how are they determined and regulated (7)? There is already evidence from studies of a growth factor gene and its receptor that parental genomic imprinting plays a role in growth regulation (8). What further directions may emerge to guide the physician so that nutrient intakes may be controlled more delicately? Such directions may supplement our present reliance on monitoring growth and development, relevant nutrient blood levels and turnover rates, and energy metabolism and balance studies relative to our present perceived norms.

The purpose of this volume is to survey recent nutritional research; and to identify, and discuss some of the new questions raised in the nutrition of the low birthweight infant.

PAUL R. SWYER, M.D., FRCP(C), FRCP
Toronto, Ontario, Canada

REFERENCES
Foreword

The feeding of low birthweight infants is, for several reasons, one of the most important aspects in the whole field of nutrition.

First, in industrialized countries the percentage of babies of low birthweight is currently below 10%, but in all but a few of the less developed countries this figure climbs to 20%. From these statistics it is easy to calculate that about 20% of births worldwide—more than 25 million babies—are of low birthweight.

Secondly, low birthweight infants who do survive the critical days immediately following birth also run the risk of having impaired development. It is becoming increasingly common to implicate nutrition as an important factor in this, especially with regard to the quantity of macronutrients (protein, and fat for energy) and micronutrients (long-chain polyunsaturated fatty acids, certain amino acids, vitamins, and trace minerals) available to these infants during early postnatal life.

Another important point is that a low birthweight infant, unlike a normal, healthy baby for whom maternal milk is the natural optimal food, requires more than mother’s milk to achieve a growth rate close to that observed in utero.

Finally, the effects of nutrition are far more clearly demonstrated in low birthweight infants than in normal, healthy term infants, and are easier to monitor because they are often in hospital for several weeks. The fact that the rate of growth is very rapid for such babies further amplifies all the positive, as well as the negative, effects of the nutrition being provided.

For a combination of all these reasons, and also because the discussions following the chapters are particularly animated and throw new light on several subjects, putting them into broader perspective, many of the topics covered in this book will also be useful for pediatricians and nutritionists involved in the care of older, larger babies.

Pierre R. Guesry, M.D.
Vice President, Nestec Ltd.
Vevey, Switzerland