THE NUTRITION SOCIETY TEXTBOOK SERIES

Introduction to Human Nutrition

Third Edition

Edited by **Susan A. Lanham-New, Thomas R. Hill, Alison M. Gallagher, and Hester H. Vorster**

Foreword by **The Earl of Selborne GBE FRS DL**

THE NUTRITION SOCIETY
Advancing Nutritional Science

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Introduction to Human Nutrition

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Introduction to Human Nutrition

Third Edition

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Contents

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Preface

I am absolutely delighted in my capacity as Editor-in-Chief (E-i-C) of the Nutrition Society Textbook Series to introduce the 3rd Edition of *Introduction to Human Nutrition* (IHN3e). The production of this Third Edition represents a significant milestone for the Society's Textbook Series, given that it is now exactly twenty years on since the production of the 1st Edition of IHN and a decade since the production of the 2nd Edition of IHN.

The Editorial Team of *Introduction to Human Nutriton* 3rd Edition, namely Professor Alison Gallagher (University of Ulster), Professor Thomas Hill (University of Newcastle) and Professor Hester Vorster (North-West University) have been absolutely fantastic; meticulously ensuring that each chapter is updated & accurate, and ensuring that new aspects of IHN3e are also brought into the Book including chapters on physical activity and phytochemicals. IHN3e comprises of a total of 17 chapters, each with their own unique summary of the take home messages. How indebted we are to have so many experts in the Field who have written chapters to make IHN3e a complete and thorough review of the area of Nutritional Sciences - a must read!

IHN3e is intended for those with an interest in nutritional science whether they are nutritionists, food scientists, dietitians, medics, nursing staff or other allied health professionals. We hope that both undergraduate and postgraduate students will find the book of great help with their respective studies and that the book will really put nutrition science as a *discipline* into context.

It is a great honour for our 3rd Edition of IHN to have the Foreword written by the The Earl of Selborne GBE FRS DL and we are most grateful to him for his support of our work at the Society, particularly given his position as Vice-President of the Foundation for Science and Technology and as a Fellow of the Royal Society. We are most grateful to the following individuals for their support and most generous Forewords in Public Health Nutrition2e, Sport and Exercise Nutrition1e, Clinical Nutrition2e and Nutrition Research Methods1e; namely – Her Royal Highness The Princess Royal; Professor Richard Budgett OBE, Chief Medical Officer for the London 2012 Olympic and Paralympic Games and now Medical and Scientific Director at the International Olympic Committee (IOC) based in Lausanne, Switzerland; Dame Sally Davies, Chief Medical Officer (CMO) for England, and the UK Government's Principal Medical Adviser; Professor Lord John Krebs, Principal, Jesus College, University of Oxford and our first Chairman of the UK Food Standards Agency. We are now planning ahead with respect to the production of the 3rd Edition of Nutrition and Metabolism and the 2nd Edition of Sport and Exercise Nutrition as well as bringing a *seventh* book to the Textbook Series!

The Society is most grateful to the Textbook publishers, Wiley-Blackwell for their continued help with the production of the textbook and in particular: James Watson – Senior Commissioning Editor; Jennifer Seward - Senior Project Editor; Baskar Anandraj - Production Editor. In addition, I would like to acknowledge formally my great personal appreciation to: Professor G.Q. Max Lu AO, FRSC, FIChemE, Vice-Chancellor & President of the University of Surrey; Professor Michael Kearney MA, PhD, CPhys, FInstP, CEng, FIET, FIMA, Provost & Executive Vice-President of the University of Surrey; Professor Helen Griffiths BSc, PhD, FRSB, Executive Dean of the Faculty of Health & Medical Sciences, University of Surrey for their respective great encouragement of the nutritional sciences field in general, especially in light of Surrey's success in the 2017/2018 Queen's Anniversary Prize for our work in *Food and Nutrition for Health*, and for their support of the Textbook Series production in particular.

Sincerest appreciation indeed to the Nutrition Society President, Professor Philip Calder (University of Southampton) and President-Elect, Professor Julie Lovegrove (University of Reading) for their great support and belief in the Textbook Series. With special thanks to past-Honorary Publications Officer, Professor Paul Trayhurn (just announced as the first recipient of the Nutrition Society Sir Frederick Gowland Hopkins Award) for his tremendous wise

counsel to me during the six years we have worked together on the Textbooks and to the present-Honorary Publications Officer Professor Jayne Woodside (Queen's University, Belfast) for being such a great sounding board and I look forward to working with her going forward on the production of further Editions of the Textbooks. And finally an enormous thank you indeed to: Mark Hollingsworth MBA, FInstLM, Chief Executive Officer & Company Secretary of the Nutrition Society for his unstinting support of the Textbook Series and to Cassandra Ellis MSc RNutr (Public Health), Deputy Editor on the Textbook Series for her pivotal continued contribution to the development of the Series.

Finally, as I always write and absolutely do not forget (ever, ever!), the Textbook Series is indebted to the forward thinking focus that Professor Michael Gibney (University College Dublin) had at that time of the Textbook Series development. It remains such a tremendous privilege for me to continue to follow in his footsteps as the second E-i-C.

I really hope that you will find the textbook a great resource of information and inspiration …… please enjoy, and with so many grateful thanks to all those who made it happen!

With my warmest of wishes indeed

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Series Foreword

In 1941, a group of leading physiologists, biochemists and medical scientists recognised that the emerging discipline of Nutrition needed its own Learned Society; hence The Nutrition Society was established. The mission was, and remains, "*to advance the scientific study of nutrition and its application to the maintenance of human and animal health*". The Nutrition Society is the largest Learned Society for Nutrition in Europe and is internationally respected for its scientific publications, conferences and training workshops.

The Society's first journal, *The Proceedings of the Nutrition Society* published in 1944, records the scientific presentations made to the Society. Shortly afterwards, in 1947, the *British Journal of Nutrition* was established for the publication of primary research on all aspects of human and animal nutrition by scientists from around the world. Recognising the needs of students and their teachers for authoritative reviews on topical issues in nutrition, the Society began publishing *Nutrition Research Reviews* in 1988. The journal *Public Health Nutrition*, the first international journal dedicated to this important and growing area, was subsequently launched in 1998. The Society's first open access journal, the *Journal of Nutritional Science*, was launched in 2012. The Society is constantly evolving in response to emerging areas of nutritional science and has most recently launched the journal *Gut Microbiome*, an open access journal published in partnership with Cambridge University Press.

The Nutrition Society Textbook Series, first established by Professor Michael Gibney (University College Dublin) in 1998 and now under the direction of the second Editor-in-Chief, Professor Susan Lanham-New (University of Surrey), continues to be an extraordinarily successful venture for the Society. This series of nutrition textbooks is designed for use worldwide and this has been achieved by translating the Textbook Series into many different languages including Spanish, Greek, Portuguese, Italian and Indonesian. The success of the Textbook Series is a tribute to the quality of the authorship, and the value placed on them in the UK and Worldwide as a core educational tool and a resource for practitioners.

I am very pleased to note Introduction to Human Nutrition is the most successful title in the Society's textbook series with over 28,000 copies sold to date across the World in all formats and translations. For many years I was involved in monitoring and determining science policy, whether as chair of a research council, as chair of the House of Lords Science and Technology Committee or as chair of the Foundation for Science and Technology. I have learned how important high-quality science is for underpinning sound policies, both in the UK and world-wide. This Textbook is uniquely placed in bringing together science and the practical application of methodologies in nutrition. It is a most valuable resource and I commend it to those working, studying and having an interest in the field of Nutritional Sciences.

The Earl of Selborne GBE FRS DL

About the Companion Website

www.wiley.com/go/lanham-new/humannutrition

- Multiple choice questions
- Short answer questions
- Essay questions

1
Introduction to Human Nutrition: A Global Perspective on Food and Nutrition

Susan A. Lanham-New, Marcela Moraes Mendes, and Hester H. Vorster

Key messages

- Human nutrition is a complex, multifaceted scientific domain indicating how substances in foods provide essential nourishment for the maintenance of life.
- To understand, study, research, and practice nutrition, a holistic integrated approach from molecular to societal level is needed.
- Optimal, balanced nutrition is a major determinant of health. It can be used to promote health and well-being, to prevent ill-health, and to treat disease.
- The study of the structure, chemical and physical characteristics, and physiological and biochemical effects of the more than 50 nutrients found in foods underpins the understanding of nutrition.
- The hundreds of millions of food- and nutrition-insecure people globally, the coexistence of undernutrition and overnutrition, and inappropriate nutritional behaviors are challenges that face the nutritionist of today.
- Nutrition practice has a firm and well-developed research and knowledge base. There are, however, many areas where more information is needed to solve global, regional, communal and individual nutrition problems.
- The development of ethical norms, standards, and values in nutrition research and practice is needed.

1.1 Orientation to human nutrition

The major purpose of this series of four textbooks on nutrition is to guide the nutrition student through the exciting journey of discovery of nutrition as a science. As apprentices in nutrition science and practice students will learn how to collect, systemise, and classify knowledge by reading, experimentation, observation, and reasoning. The road for this journey was mapped out millennia ago. The knowledge that nutrition – what we choose to eat and drink – influences our health, well-being, and quality of life is as old as human history. For millions of years the quest for food has helped to shape human development, the organisation of society and history itself. It has influenced wars, population growth, urban expansion, economic and political theory, religion, science, medicine, and technological development.

It was only in the second half of the eighteenth century that nutrition started to experience its first renaissance with the observation by scientists that intakes of certain foods, later called nutrients, and eventually other substances not yet classified as nutrients, influence the function of the body, protect against disease, restore health, and determine people's response to changes in the environment. During this period, nutrition was studied from a medical model or

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paradigm by defining the chemical structures and characteristics of nutrients found in foods, their physiological functions, biochemical reactions and human requirements to prevent, first, deficiency diseases and, later, also chronic noncommunicable diseases.

Since the late 1980s nutrition has experienced a second renaissance with the growing perception that the knowledge gained did not equip mankind to solve the global problems of food insecurity and malnutrition. The emphasis shifted from the medical or pathological paradigm to a more psychosocial, behavioral one in which nutrition is defined as a basic human right, not only essential for human development but also as an outcome of development.

In this first, introductory text, the focus is on the principles and essentials of human nutrition, with the main purpose of helping the nutrition student to develop a holistic and integrated understanding of this complex, multifaceted scientific domain.

1.2 An integrated approach

Human nutrition describes the processes whereby cellular organelles, cells, tissues, organs, systems, and the body as a whole obtain and use necessary substances obtained from foods (nutrients) to maintain structural and functional integrity. For an understanding of how humans obtain and utilise foods and nutrients from a molecular to a societal level, and of the factors determining and influencing these processes, the study and practice of human nutrition involve a spectrum of other basic and applied scientific disciplines. These include molecular biology, genetics, biochemistry, chemistry, physics, food science, microbiology, physiology, pathology, immunology, psychology, sociology, political science, anthropology, agriculture, pharmacology, communications, and economics. Nutrition departments are, therefore, often found in Medical (Health) or Social Science, or Pharmacy, or Agriculture Faculties at tertiary training institutions. The multidisciplinary nature of the science of nutrition, lying in both the natural (biological) and social scientific fields, demands that students of nutrition should have a basic understanding of many branches of science and that they should be able to integrate different concepts from these different disciplines. It implies that students should choose their accompanying subjects (electives) carefully and that they should read widely in these different areas.

1.3 A conceptional framework for the study of nutrition

In the journey of discovery into nutrition science it will often be necessary to put new knowledge, or new applications of old knowledge, into the perspective of the holistic picture. For this, a conceptual framework of the multidisciplinary nature of nutrition science and practice may be of value. Such a conceptual framework, illustrating the complex interactions between internal or constitutional factors and external environmental factors which determine nutritional status and health, is given in Figure 1.1.

On a genetic level it is now accepted that nutrients dictate phenotypic expression of an individual's genotype by influencing the processes of transcription, translation, or post-translational reactions. In other words, nutrients can directly influence genetic (DNA) expression, determining the type of RNA formed (transcription) and also the proteins synthesised (translation). For example, glucose, a carbohydrate macronutrient, increases transcription for the synthesis of glucokinase, the micronutrient iron increases translation for the synthesis of ferritin, while vitamin K increases post-translational carboxylation of glutamic acid residues for the synthesis of prothrombin. Nutrients, therefore, influence the synthesis of structural and functional proteins, by influencing gene expression within cells.

Nutrients also act as substrates and cofactors in all the metabolic reactions in cells necessary for the growth and maintenance of structure and function. Cells take up nutrients (through complex mechanisms across cell membranes) from their immediate environment, also known as the body's internal environment. The composition of this environment is carefully regulated to ensure optimal function and survival of cells, a process known as homeostasis, which gave birth to a systems approach in the study of nutrition.

Nutrients and oxygen are provided to the internal environment by the circulating blood, which also removes metabolic end-products and harmful substances from this environment for

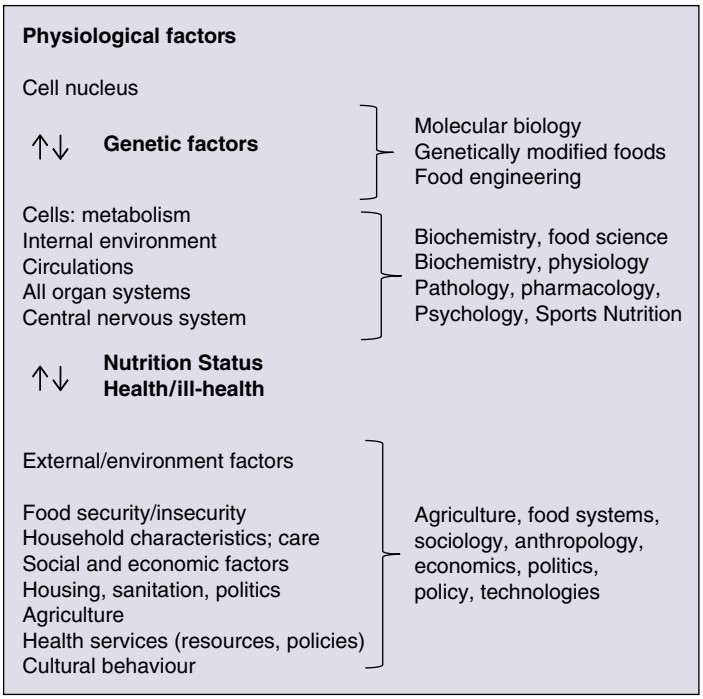

Figure 1.1 Conceptual framework for a holistic, integrated understanding of human nutrition.

excretion through the skin, the kidneys, and the large bowel.

The concerted function of different organs and systems of the body ensures that nutrients and oxygen are extracted or taken up from the external environment and transferred to the blood for transport and delivery to the internal environment and cells. The digestive system, for example, is responsible for the ingestion of food and beverages, the breakdown (digestion and fermentation) of these for extraction of nutrients, and the absorption of the nutrients into the circulation, while the respiratory system extracts oxygen from the air. These functions are coordinated and regulated by the endocrine and central nervous systems in response to the chemical and physical composition of the blood and internal environment, and to cellular needs.

The health or disease state of the different organs and systems will determine the nutrient requirements of the body as a whole.

The central nervous system is also the site or "headquarters" of the higher, mental functions related to conscious or cognitive, spiritual, religious, and cultural behaviors, which will determine, in response to the internal and external environments, what and how much will be eaten. What and how much is eaten will further depend on what is available, influenced by a host of factors determining food security. All of these factors, on an individual, household, community, national, or international level, shape the external environment.

During the first renaissance of nutrition, emphasis was placed on the study of nutrients and their functions. A medical, natural science, or biological model underpinned the study of the relationships between nutrition and health or ill-health. During the second renaissance, these aspects are not neglected, but expanded to include the study of all other external environmental factors that determine what and how much food and nutrients are available on a global level. These studies are underpinned by social, behavioral, economic, agricultural, and political sciences. The study of human nutrition therefore seeks to understand the complexities of both social and biological factors on how individuals and populations maintain optimal function and health, how the quality, quantity and balance of the food supply are influenced, what happens to food after it is eaten, and the way that

diet affects health and well-being. This integrated approach has led to a better understanding of the causes and consequences of malnutrition including the double burden of over and under nutrition, and of the relationship between nutrition and health.

1.4 Relationship between nutrition and health

Figure 1.2 shows that individuals can be broadly categorised into having optimal nutritional status or being undernourished, overnourished, or malnourished. The major causes and consequences of these nutritional states are indicated. It is important to realise that many other lifestyle and environmental factors, in addition to nutrition, influence health and well-being, but nutrition is a major, modifiable, and powerful factor in promoting health, preventing and treating disease, and improving quality of life.

1.5 Nutrients: the basics

People eat food, not nutrients; however, it is the combination and amounts of nutrients in consumed foods that determine health. To read one must know the letters of the alphabet; to do sums one must be able to count, add, subtract, multiply, and divide. To understand nutrition, one must know about nutrients. The study of nutrients, the ABC and numeric calculations of nutrition, will form a major part of the student's nutrition journey, and should include:

- the chemical and physical structure and characteristics of the nutrient;
- the food sources of the nutrient, including food composition, the way in which foods are grown, harvested, stored, processed and prepared, and the effects of these on nutrient composition and nutritional value;
- the digestion, absorption, circulatory transport, and cellular uptake of the nutrient, as well as regulation of all these processes;

Nutritional situation		Health consequences, outcomes
Optimum nutrition Food-secure individuals with adequate, balanced and prudent diets	→	Health, well-being, normal development, high quality of life
Undernutrition: hunger Food-insecure individuals living in poverty, ignorance, politically unstable environments, disrupted societies, war	→	• Decreased physical and mental development • Compromised immune systems • Increased infectious diseases • Vicious circle of undernutrition, underdevelopment, poverty
Overnutrition Overconsumption of food, especially macronutrients, plus: • low physical activity • smoking, stress, alcohol abuse	→	Obesity, metabolic syndrome, cardiovascular disease, type 2 diabetes mellitus, certain cancers: chronic NCDs, often characterized by overnutrition of macronutrients and undernutrition of micronutrients
Malnutrition Nutrition transition: Individuals and communities previously food insecure → confronted with abundance of palatable foods → some undernourished, others too many macronutrients and too few micronutrients	→	Double burden of infectious diseases plus NCDs, often characterized by overnutrition of macronutrients and undernutrition of micronutrients

Figure 1.2 Relationship between nutrition and health. NCD, noncommunicable disease.

- the metabolism of the nutrient, its functions, storage, and excretion;
- physiological needs (demands or requirements) for the nutrient in health and disease, and during special circumstances (pregnancy, lactation, sport events), as well as individual variability (genetic factors);
- interactions with other nutrients, nonnutrients (phytochemicals), antinutrients, and drugs;
- the consequences of underconsumption and over-consumption of nutrients;
- the therapeutic uses of the nutrient;
- factors influencing food and nutrition security and food safety;
- dietary behavior and cultural patterns.

There are more than 50 known nutrients (including amino acids and fatty acids) and many more chemicals in food thought to influence human function and health (Box 1.1). Nutrients do not exist in isolation, except for water and others in some pharmaceutical preparations. In foods, in the gut during digestion, fermentation and absorption, in the blood during transport, and in cells during metabolism, nutrients interact with each other. Therefore, a particular nutrient should not be studied in isolation, but integrated with other nutrients and seen in the context of total body function. The study of nutrition also includes how to determine nutrient requirements to make recommendations for intakes and how nutritional status is monitored by measuring intakes, anthropometry, body composition, biochemical markers reflecting nutritional status, and the clinical signs of malnutrition.

This knowledge of nutrients and their functions will enable the nutritionist to advise individuals what and how much to eat. However, this knowledge is not sufficient to understand and address the global problem of malnutrition facing mankind today. This perception has resulted in the cultivation of social science disciplines to support knowledge from the biological sciences to address global malnutrition.

1.6 Global malnutrition

It is a major tragedy that millions of people currently live with hunger, and fear starvation. This is in spite of the fact that food security or "access for all at all times, to a sustainable supply of nutritionally adequate and safe food for normal physical and mental development and healthy, productive lives" is a basic human right embedded in the constitution of most developing countries. It is also despite the fact that sufficient food is produced on a global level (see Box 1.2). Food insecurity is an obstacle to human rights, quality of life, and human dignity. Chapter 15 provides a thorough overview of nutrition-related diseases in developed and developing countries.

The World Health Organization estimates that, during the last decade, around 1.9 billion adults are overweight or obese, while 850 million are undernourished. More than 52 million children under five years of age are wasted, 17 million are severely wasted and 155 million are stunted, while 41 million are overweight or obese. An estimated two billion people around

Box 1.1 Classes of nutrients for human nutrition

Class/category	Subclass/category	Nutrient examples
Carbohydrates (macronutrients)	Monosaccharides Disaccharides Polysaccharides	Glucose, fructose, galactose Sucrose, maltose, lactose Starch and dietary fibre
Proteins (macronutrients)	Plant and animal source proteins	Amino acids (n = 20): aliphatic, aromatic, sulfur-containing, acidic, basic
Fats and oils (lipids) (macronutrients)	Saturated fatty acids Monounsaturated fatty acids Polyunsaturated fatty acids (n-3, n-6, n-9)	Palmitic and stearic acid Oleic (cis) and elaidic (trans) fatty acids Linoleic, α-linolenic, arachidonic, eicosapentaenoic, docosahexaenoic acid
Minerals (micronutrients)	Minerals and electrolytes Trace elements	Calcium, sodium, phosphate, potassium, iron, zinc, selenium, copper, manganese, molybdenum, fluoride, chromium
Vitamins (micronutrients)	Fat soluble Water soluble	Retinol (A), calciferols (D), tocopherols (E), vitamin K Ascorbic acid (C), thiamine (B_1), riboflavin (B_2), niacin (B_3), pyridoxine (B_6), folate, cobalamin (B_{12})
Water	Water	Water

Box 1.2

Food insecurity: when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life (FAO, 2011). Food security: when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO, 1996).

the world are at risk of iodine deficiency, iron anaemia affects around 800 million children and women, and vitamin A deficiency was endemic in 60 countries with 190 million pre-school age children and 19.1 million pregnant women deficient. This has led to several global initiatives and commitments, spearheaded by a number of United Nations organisations, to reduce global undernutrition, food insecurity, hunger, starvation, and micronutrient deficiencies. Some progress has been made in reducing these numbers, but the problems are far from solved. Some of the initiatives are:

1990
: The United Nations Children's (Emergency) Fund (UNICEF)-supported World Summit for Children, with a call to reduce severe and moderate malnutrition among children under five years of age by half the 1990 rate by the year 2000, including goals for the elimination of micronutrient malnutrition;

1992
: the World Health Organization/Food and Agriculture Organization (WHO/FAO) International Conference on Nutrition that reinforced earlier goals and extended them to the elimination of death from famine;

1996
: the FAO-supported World Food Summit during which 186 heads of state and governments pledged their political will and commitment to a plan of action to reduce the number of undernourished people to half their 1996 number by 2015;

1997
: the establishment in of the Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) and their Interagency Working Group (IAWG), which consists of 26 international organisations and agencies with a shared commitment to reduce food insecurity and vulnerability and its multidimensional causes rooted in poverty; information about these initiatives can be accessed at: http://www.fao.org/;

2000
: Millennium Development Goals: the United Nations articulated eight goals, ranging from halving extreme poverty and hunger, halting the spread of the human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) and providing universal primary education, to be reached by the target date of 2015; the blueprint of these goals was agreed to by all 191 United Nations member states at that time and 22 leading development institutions. Information about these initiatives can be accessed at: http://www.un.org/millenniumgoals/;

2015
: Sustainable Development Goals: developed by the United Nations to succeed the Millennium Development Goals (MDGs), address global challenges including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice with 17 global goals to be achieved by 2030. Information about these initiatives can be accessed at: https://sustainabledevelopment.un.org/

The most recent report from the FAO, published in 2018 indicated that for the third year in a row, there has been a rise in world hunger. The absolute number of undernourished people (those facing chronic food deprivation) has increased to nearly 821 million in 2017, from around 804 million in 2016. These are levels equivalent to 1997–1999 numbers, over two decades ago, when there were 815 million undernourished people in the world. In 2017, a total of 155 million children were stunned (reduced growth rate due to malnutrition) and 52 million children under five were affected by wasting (low weight for height), consequently putting them at a higher risk of mortality. In contrast, adult obesity rates continue to rise each year, from 11.7 percent in 2012 to 13.2 percent in 2016. In 2017 more than one in eight adults (672 million) in the world was classified as obese.

Clearly, this is a huge challenge for food and nutrition scientists and practitioners. It would need a holistic approach and understanding of the complex, interacting factors that contribute to malnutrition on different levels. These include immediate, intermediate, underlying, and basic causes underlined in Figure 1.3.

To address these causes of undernutrition food-insecure and hungry communities and individuals must be empowered to be their own agents of food security and livelihood development. Complicating the task of fighting food insecurity and hunger are natural disasters such as droughts, floods, cyclones and extreme temperatures, ongoing wars and regional

Individual level or immediate causes	Household level or intermediate causes
• Food and nutrient intake • Physical activity health status, • Social structures • Care • Taboos • Growth • Personal choice	• Family size and composition • Gender equity • Rules of distribution of food within the household • Income • Availability of food • Access to food
National level or underlying causes	**International level or basic causes**
• Health, education, sanitation • Agriculture and food security • War • Political instability • Urbanisation • Population growth • Distribution and conflicts • War • Natural disasters • Decreased resources	• Social, economic and political structures • Trade agreements • Population size • Population growth distribution • Environmental degradation

Figure 1.3 immediate, intermediate, underlying, and basic causes that contribute to malnutrition.

conflicts, as well as the devastating impact of HIV and AIDS, especially in sub-Saharan Africa.

In many developing countries, indigenous people have changed their diets and physical activity patterns to those followed in industrialised countries. Supplementary feeding programmes in these countries have often been associated with increasing trends towards obesity, insulin resistance, and the emergence of chronic diseases of lifestyle in some segments of these populations, while other segments are still undernourished.

The coexistence of undernutrition and overnutrition, leading to a double burden of infectious and chronic, noncommunicable diseases, and the multifactorial causes of malnutrition, call for innovative approaches to tackle both undernutrition and overnutrition in integrated nutrition and health-promoting programmes, focusing on optimal nutrition for all.

1.7 Relationship between nutrition science and practice

The journey through the scientific domain of nutrition will, at a specialised stage, fork into different roads. These roads will lead to the different scopes or branches of nutrition science that are covered in the Nutrition Society Textbook Series. These different branches of nutrition science could lead to the training of nutrition specialists for specific practice areas.

The main aim of nutrition professionals is to apply nutrition principles to promote health and well-being, to prevent disease, and/or to restore health (treat disease) in individuals, families, communities and the population. To help individuals or groups of people to eat a balanced diet, in which food supply meets nutrient needs, involves application of nutrition principles from a very broad field to almost every facet of human life. It is therefore not surprising that these different branches or specialties of nutrition have evolved and are developing. They include clinical nutrition, community nutrition, public health, and public nutrition. It can be expected that there will be overlap in the practice areas of these specialties.

- The clinical nutritionist will counsel individuals from a biomedical–disease–behavioral paradigm to promote health, prevent disease, or treat disease. The clinical nutritionist will mostly work within the health service (facility-based settings such as hospitals, clinics, private practice).
- The community nutritionist, with additional skills from the psychosocial behavioral sciences, should be aware of the dynamics within

particular communities responsible for nutritional problems. These would include household food security, socioeconomic background, education levels, childcare practices, sanitation, water, energy sources, healthcare services, and other quality-of-life indicators. The community nutritionist will design, implement, and monitor appropriate, community-participatory programmes to address these problems.

- The public health or public nutritionist covers the health and care practice areas but will also be concerned with food security (agricultural) and environmental issues on a public level. The public health or public nutritionist will, for example, be responsible for nutrition surveillance, and the design, implementation, and monitoring of dietary guidelines that address relevant public health problems. A background knowledge in economics, agriculture, political science, and policy design is essential for the formulation and application of nutrition policy in a country.
- The sports nutritionist will work in sport and exercise nutrition, and will need to understand the specific science and physiology involved to apply into their practice with sports, athletes and other exercise enthusiasts.

Many developing countries will not have the capacity or the financial resources to train and employ professionals for different specialties. However, future specialised training and employment of different professionals could result in a capacity to address nutritional problems more effectively.

1.8 Nutrition milestones: the development of nutrition as a science

Ancient beliefs

Throughout human existence people have attributed special powers to certain foods and developed beliefs and taboos regarding foods. These were often based on climatic, economic, political, or religious circumstances and principles, but also on observations regarding the relationship between the consumption of certain foods and health.

Recorded examples are ancient Chinese and Indian philosophers who advised on the use of warming and cooling foods and spices for certain conditions and for "uplifting the soul," the Mosaic laws documented in the Old Testament which distinguished between clean and unclean foods, the fasting and halal practices of Islam, and the Benedictine monks from Salerno who preached the use of hot and moist versus cold and dry foods for various purposes. Hippocrates, the father of modern medicine, who lived from 460 to about 377 BC, and later Moses Maimonides, who lived in the twelfth century, urged people to practice abstemiousness and a prudent lifestyle. They, and others, advised that, for a long and healthy life, one should avoid too much fat in the diet, eat more fruit, get ample sleep, and be physically active – advice that is still incorporated in the modern, science-based dietary guidelines of the twenty-first century!

Cultural beliefs

The perception that food represents more than its constituent parts is still true. Eating together is an accepted form of social interaction. It is a way in which cultural habits and customs, social status, kinship, love, respect, sharing, and hospitality are expressed. Scientists and nutrition professionals realise that, when formulating dietary guidelines for traditional living people, cultural beliefs and taboos should be taken into account and incorporated. There are numerous examples of traditional food habits and diets, often based on what was available. Today, with the world becoming a global village, cultures have learned from each other, and dietary patterns associated with good health, such as the Mediterranean diet, are becoming popular among many cultures.

The first renaissance: development of an evidence base

The knowledge of the specific health effects of particular diets, foods, and nutrients is now firmly based on the results of rigid scientific experimentation. Nutrition developed gradually as a science, but advanced with rapid strides during the twentieth century. There are numerous meticulously recorded examples of how initial (often ancient and primitive) observations about diet and health relationships led to the discovery, elucidation of function, isolation, and synthesis of the different nutrients. Perhaps the most often

quoted example is James Lind's description in 1772 of how citrus fruit could cure and prevent scurvy in seamen on long voyages. The anti-scurvy factor (ascorbic acid or vitamin C) was only isolated in 1921, characterised in 1932, and chemically synthesised in 1933. Other examples of nutritional milestones are the induction of beriberi in domestic fowl by Eijkman in 1897, the observation of Takaki in 1906 that beriberi in Japanese sailors could be prevented by supplementing their polished rice diets with wheat bread, and, eventually, the isolation of the responsible factor, thiamine or vitamin B_1, by Funk in 1911. Others are the Nobel Prize-winning discovery by Minot and Murphy in 1926 that pernicious anemia is a nutritional disorder due to a lack of vitamin B_{12} in the diet, the description of kwashiorkor as a protein-deficiency state by Cecily Williams in 1935, and the discovery of resistant starch and importance of colonic fermentation for humans by nutritionists of the Dunn Clinical Nutrition Centre in the 1980s.

The history of modern nutrition as practised today is an exciting one to read, and students are encouraged to spend some time on it. It is often characterised by heartbreaking courage and surprising insights. An example of the former is the carefully documented clinical, metabolic, and pathological consequences of hunger and starvation by a group of Jewish doctors in 1940 in the Warsaw ghetto: doctors who were themselves dying of hunger. An example of the latter is the research by Price, an American dentist, who tried to identify the dietary factors responsible for good dental and overall health in people living traditional lifestyles. He unwittingly used a fortigenic paradigm in his research, examining the strengths and factors that keep people healthy, long before the term was defined or its value recognised.

At present, thousands of nutrition scientists examine many aspects of nutrition in laboratories and field studies all over the world and publish in more than 100 international scientific nutrition journals. This means that nutrition science generates new knowledge based on well-established research methodologies. The many types of experiments, varying from molecular experimentation in the laboratory, through placebo-controlled, double-blinded clinical interventions, to observational epidemiological surveys, and experiments based on a health (fortigenic) or a disease (pathogenic) paradigm, will be addressed in this volume (Chapter 13). The peer-review process of published results has helped in the development of guidelines to judge how possible, probable, convincing, and applicable are the results from these studies. New knowledge of nutrients, foods, and diet relationships with health and disease is, therefore, generated through a process in which many scientists examine different pieces of the puzzle all over the world in controlled scientific experiments. Therefore, nutrition practice today has a firm research base that enables nutritional professionals to practice evidence-based nutrition.

The second renaissance: solving global malnutrition

There is little doubt that improved nutrition has contributed to the improved health and survival times experienced by modern humans. However, global figures on the prevalence of both undernutrition and overnutrition show that millions of people do not have enough to eat, while the millions who eat too much suffer from the consequences of obesity. It is tempting to equate this situation to the gap between the poor and the rich or between developing and developed countries, but the situation is much more complex. Obesity, a consequence of overnutrition, is now a public health problem not only in rich, developed, food-secure countries but also in developing, food-insecure countries, especially among women. Undernutrition, the major impediment to national development, is the biggest single contributor to childhood death rates, and to impaired physical growth and mental development of children in both developing and developed countries. Moreover, a combination of undernutrition and overnutrition in the same communities, in single households, and even in the same individual is often reported. Examples are obese mothers with undernourished children and obese women with certain micronutrient deficiencies. The perception that these global problems of malnutrition will be solved only in innovative, multidisciplinary, and multisectorial ways has led to the second, very recent renaissance in nutrition research and practice.

1.9 Future challenges for nutrition research and practice

Basic, molecular nutrition

The tremendous development in recent years of molecular biology and the availability of sophisticated new techniques are opening up a field in which nutrient–gene interactions and dietary manipulation of genetic expression will receive increasing attention. The effects of more than 12 000 different substances in plant foods, not yet classified as nutrients, will also be examined. These substances are produced by plants for hormonal, attractant, and chemoprotective purposes, and there is evidence that many of them offer protection against a wide range of human conditions. It is possible that new functions of known nutrients, and even new nutrients, may be discovered, described, and applied in the future.

Clinical and community nutrition

Today, the focus has moved from simple experiments with clear-cut answers to studies in which sophisticated statistics have to be used to dissect out the role of specific nutrients, foods, and diets in multifactorial diseases. Nutrition epidemiology is now established as the discipline in which these questions can be addressed. A number of pressing problems will have to be researched and the results applied, for example:

- the biological and sociological causes of childhood obesity, which is emerging as a global public health problem;
- the nutrient requirements of the elderly: in the year 2017, more than 962 million of the Earth's inhabitants were older than 60 years and the number is expected to double by 2050 reaching nearly 2.1 billion (WHO,2017); to ensure a high-quality life in the growing elderly population, much more needs to be known about their nutrient requirements;
- the relationships between nutrition and immune function and how improved nutrition can help to defend against invading microorganisms; in the light of the increasing HIV/AIDS pandemic, more information in this area is urgently needed;
- dietary recommendations: despite sufficient, convincing evidence about the effects of nutrients and foods on health, nutritionists have generally not been very successful in motivating the public to change their diets to more healthy ones. We need to know more about why people make certain food choices in order to design culturally sensitive and practical dietary guidelines that will impact positively on dietary choices. The food-based dietary guidelines that are now being developed in many countries are a first step in this direction.

Public health nutrition

The single most important challenge facing mankind in the future is probably to provide adequate safe food and clean water for all in an environmentally safe way that will not compromise the ability of future generations to meet their needs. In addition to the hundreds of millions not eating enough food to meet their needs for a healthy, active life, an additional 80 million people have to be fed each year. The challenge to feed mankind in the future calls for improved agriculture in drought-stricken areas such as sub-Saharan Africa, the application of biotechnology in a responsible way, interdisciplinary and intersectorial cooperation of all involved, and a better distribution of the food supply so that affordable food is accessible by all. The need for sustained economic growth in poor countries is evident.

Nutritionists have an important part to play in ensuring food security for all, a basic human right, in the future. One of their main functions would be to educate and inform populations not to rely too heavily on animal products in their diet, the production of which places a much heavier burden on the environment than plant foods. A major challenge would be to convince political leaders and governments that addressing undernutrition (the major obstacle in national development) in sustainable programmes should be the top priority in developing and poor communities. Another challenge is to develop models based on the dynamics within communities and, using a human rights approach, to alleviate undernutrition without creating a problem of overnutrition. There are examples where such models, incorporated

<table>
<tr><td colspan="2">Microbial contamination
Bacteria and Mould (fungi) producing toxins and aflatoxins
Toxins cause “food poisoning” and aflatoxins are carcinogenic</td></tr>
<tr><td>Natural toxins
Such as cyanide in cassava, solanine in potatoes; can be produced by abnormal circumstances, could be enzyme inhibitors or antivitamins</td><td>Agricultural residues
Pesticides such as DDT or hormones used to promote growth such as bovine somatotrophin</td></tr>
<tr><td>Environmental contamination
Heavy metals and minerals
Criminal adulteration, industrial pollution
Substances from packaging materials
Changes during cooking and processing of foods</td><td>Intentional additives
Artificial sweeteners
Preservatives
Phytochemicals
Modified carbohydrates (for functional foods)</td></tr>
</table>

Figure 1.4 Potential hazardous substances in food. DDT, dichloro-diphenyl-trichloroethane.

into community development programmes, have been very successful (e.g., in Thailand).

Functional foods: a new development

Functional foods are new or novel foods, developed to have specific health benefits, in addition to their usual functions. Examples are spreads with added phytosterols, to lower serum low-density lipoprotein cholesterol and the risk of coronary heart disease, and the development of starchy products with resistant starch and lower glycemic indices, to help control blood glucose levels. The development and testing of functional foods is an exciting new area. These foods may help to improve or restore nutritional status in many people. However, much more should be known about suitable biomarkers to test their efficacy, variability in human response to specific food products, safety, consumer understanding, and how their health messages must be formulated, labeled, and communicated.

Food safety

The continued provision of safe food, free from microorganisms, toxins, and other hazardous substances that cause disease, remains a huge challenge (see chapter 15 for more on food safety). Recent experiences with animals suffering from bovine spongiform encephalopathy (BSE or mad cow disease) or from foot-and-mouth disease, or birds infected with the influenza A virus (bird flu), have shown how quickly a national problem can become an international one because of global marketing of products. The list of possible hazardous substances in foods emphasizes the need for continuous monitoring of the food supply by health officials (Figure 1.4).

Supplements and food fortification

A dietary or nutritional supplement is defined as a product with the purpose of supplementing the diet, providing additional nutrients that may be missing from it or not being consumed in sufficient quantities. Dietary supplements might contain vitamins, minerals, herbs, amino acids, enzymes, fibre, and fatty acids. They are available in a variety of forms, including traditional tablets, capsules, powders, drinks and supplement bars. It has been estimated that millions of people around the world take vitamins and dietary supplements to achieve good health, ease our illnesses and defy ageing. In 2009 the market for dietary supplements and vitamins was worth more than £670 million in the UK alone.

Food fortification increases the content of an essential micronutrient (i.e. vitamins and minerals) in a food to improve the nutritional quality of the food and provide a public health benefit with minimal risk to health. Bio-fortification is the process by which the nutrient levels in crops during plant growth, rather than through manual means as in conventional fortification, by agronomic practices, conventional plant breeding, or modern biotechnology. Food fortification in general provides a potentially effective strategy to improve the nutritional status of populations.

1.10 Perspectives on the future

Nutrition research and practice, although it has been around for many years, is in its infancy as a basic and applied scientific discipline. The present and future nutrition student will take part in this very exciting second renaissance of nutrition and see its maturation. However, to influence effectively the nutrition and health of individuals and populations, the nutritionist will have to forge links and partnerships with other health professionals and policy-makers, and will have to develop lateral thinking processes. The magnitude and complexity of nutritional problems facing mankind today demand concerted multidisciplinary and multisectorial efforts from all involved to solve them. Therefore, the principal message to take on a nutrition science journey is that teamwork is essential: one cannot travel this road on one's own; partners from different disciplines are needed. Another essential need is the continuous development of leadership in nutrition. Leaders on every level of research and practice are necessary to respond to the existing challenges of global malnutrition and to face future challenges.

The modern advances in molecular biology and biotechnology on the one hand, and the persistence of global malnutrition on the other, increasingly demand a re-evaluation of ethical norms, standards, and values for nutrition science and practice. Direction from responsible leaders is needed (Box 1.3). There is an urgent need for ethical guidelines and a code of conduct for partnerships between food industries, UN agencies, governments, and academics. These partnerships are necessary for addressing global malnutrition in sustainable programmes.

The student in nutrition, at the beginning of this journey of discovery of nutrition as a science, must make use of the many opportunities to develop leadership qualities. May this be a happy, fruitful, and lifelong journey with many lessons that can be applied in the research and practice of nutrition to make a difference in the life of all.

Box 1.3 Future challenges that require exceptional leadership

- Basic molecular nutrition
  - Nutrient–gene interactions
  - Role of phytochemicals in health
  - New nutrients? New functions?
- Community and public health nutrition
  - Childhood obesity
  - Requirements of the elderly
  - Dietary recommendations
  - Nutrition of patients with human immunodeficiency virus/ acquired immunodeficiency syndrome
  - Noncommunicable diseases including cardiovascular diseases (like heart attacks and stroke), cancer, chronic respiratory diseases (such as chronic obstructed pulmonary disease and asthma) and diabetes.
- Public nutrition
  - To feed mankind
  - Food security
- Functional foods
  - To ensure that novel foods are effective and safe
  - Food safety
  - Continuous monitoring
- Partnerships with other disciplines to offer multidisciplinary approaches
- Nutrition research
- Leadership

Further reading

Websites

http://www.who.int/nutrition/en
https://www.un.org/nutrition/
www.fao.org/nutrition/en/
http://www.ifpri.org

2
Measuring Dietary Intake

Una E. MacIntyre and Friedeburg AM. Wenhold

Key messages

- Measuring the dietary intake in free-living individuals is a complex task.
- The dietary assessment method used depends on the purpose of the study, the target group and the setting.
- All measurements of food intake are subject to sources of error.
- The existence of error means that it is always important to be aware of and, whenever possible, to assess the nature and magnitude of the error.
- To increase our understanding of the error associated with measurements of food intake it is also necessary to use physiological and biochemical markers of dietary intake.
- To evaluate dietary intake data effectively it is important to collect sufficient additional data to allow individuals to be identified not only by age and gender, but also by body mass index, physical activity, and supplement use.
- Dietary assessment is a growing field. New formats, tools, techniques, and strategies are constantly emerging.

2.1 Introduction

The purpose of this chapter is to describe the various ways in which one can determine what people eat. The task may be to find out about the national food supply, the usual intake of a group or a household, or the intake of a given individual over a specified period.

The many reasons for finding out about the food that people eat fall into three broad categories:

- Public Health: to evaluate the adequacy and safety of the food that people eat at national or community level, to formulate national or local food production and/or supply policies and to identify the need for or to evaluate nutrition-based intervention programmes.
- Clinical: to assist with the prevention, diagnosis, and management of diet-related conditions.
- Research: to study the interrelationships between dietary intake and physiological function or ill-health under controlled (experimental) or in real life (field) conditions. The kind and amount of dietary intake data required differ in each situation and may be at the national, community, household, or individual level.

Assessment of nutritional status

Nutritional health is maintained by a state of equilibrium in which nutrient intake is balanced by nutritional requirements. Malnutrition occurs when net nutrient intake is less than requirements (undernutrition) or exceeds requirements (overnutrition). Both under- and overnutrition lead to metabolic changes which have acute and chronic consequences for health.

There is no ideal tool to measure a person's nutritional status accurately. Attempts to predict the influence of malnutrition based on single measurements fail to consider the many interacting factors between nutrition and disease state. For this reason, it is necessary to look at several different measurements in order to

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Companion website: www.wiley.com/go/lanham-new/humannutrition

Box 2.1

Food intake: Foods and beverages consumed by a population, community, household or individual.
Nutrient intake: The energy and individual macro and micronutrient intake, whether provided by foods and beverages consumed and derived from either direct analysis or food composition tables/databases or from nutritional supplements.
Dietary intake: The sum of the food, beverage and nutritional supplement intake and the macro- and micronutrients, non-nutrient components and water derived therefrom.

assess a person's nutritional status. This process is known as the A, B, C, D of nutritional assessment:

- **a**nthropometry (discussed in detail in Chapter 5)
- **b**iochemical and haematological variables
- **c**linical and physical assessment
- **d**ietary intake.

Dietary intake refers to both the consumption of food, beverages, including water, and supplements (when relevant) and the energy, nutrients, and non-nutrient components provided by these foods, beverages, and supplements. Box 2.1 gives definitions of the components of dietary intake. Figure 2.1 shows the relationships between the components of dietary intake, dietary requirements, and the nutritional status of an individual.

The rest of this chapter will concentrate on the measurement of diet, that is, measuring food intake, the conversion of food intake data to energy and nutrients and methods for summarising and reporting food and/or nutrient intake information. More detailed descriptions of the assessment of nutritional status, at the population and individual level can be found in the *Public Health Nutrition* and *Clinical Nutrition* textbooks in this series.

Challenges of dietary assessment

Obtaining data on dietary intake is probably the most difficult aspect of nutritional assessment and is associated with several problems:

- "Dietary intake" is not a simple measure of one variable, such as weight or height, but requires data on the intake of many different food and beverage items.
- Dietary intake data are subject to many sources of variability, since even the same individuals eat different foods, at different times, in different places, in many different combinations, and with many different preparation methods. The net effect of all these sources of variability is that more data are needed to generate reliable results than would be the case with a less variable measure.
- We are rarely in a position to know the truth about dietary intake. With many biological measurements it is possible to check the results obtained against a reference method that is known to give accurate results or by means of an independent measure. For example, we can check an infant's birth weight by using a standard weight to confirm the accuracy of the scale or, if the information was obtained by means of a questionnaire, we may be able to check the data from official records. When assessing dietary intake, we have to rely on the individuals who eat the food to provide us with the answers to our questions. We ask individuals to remember what and how much they ate, to estimate how often they eat particular foods, or even, in some situations, to weigh or measure their food intake for a number of days. Furthermore, we rely on the individuals' ability to describe or record their food intake in detail. For this reason one of the most important considerations, when obtaining information on dietary intake from individuals, is to take all possible steps to obtain their full cooperation. It is also extremely important that individuals understand the purpose of the process and what is expected of them. This may well involve much time and effort on the part of the nutrition professional(s), but is essential for high-quality data.
- There are a number of different methods to obtain dietary intake data. Each method has its purposes, strengths, and limitations. It is, therefore, essential that the purpose of collecting dietary intake data is clearly defined, so that the most appropriate dietary assessment method is used.

It is also essential to recognise that finding out what people eat requires adequate resources. Appropriately trained personnel must be employed not only for the period of data

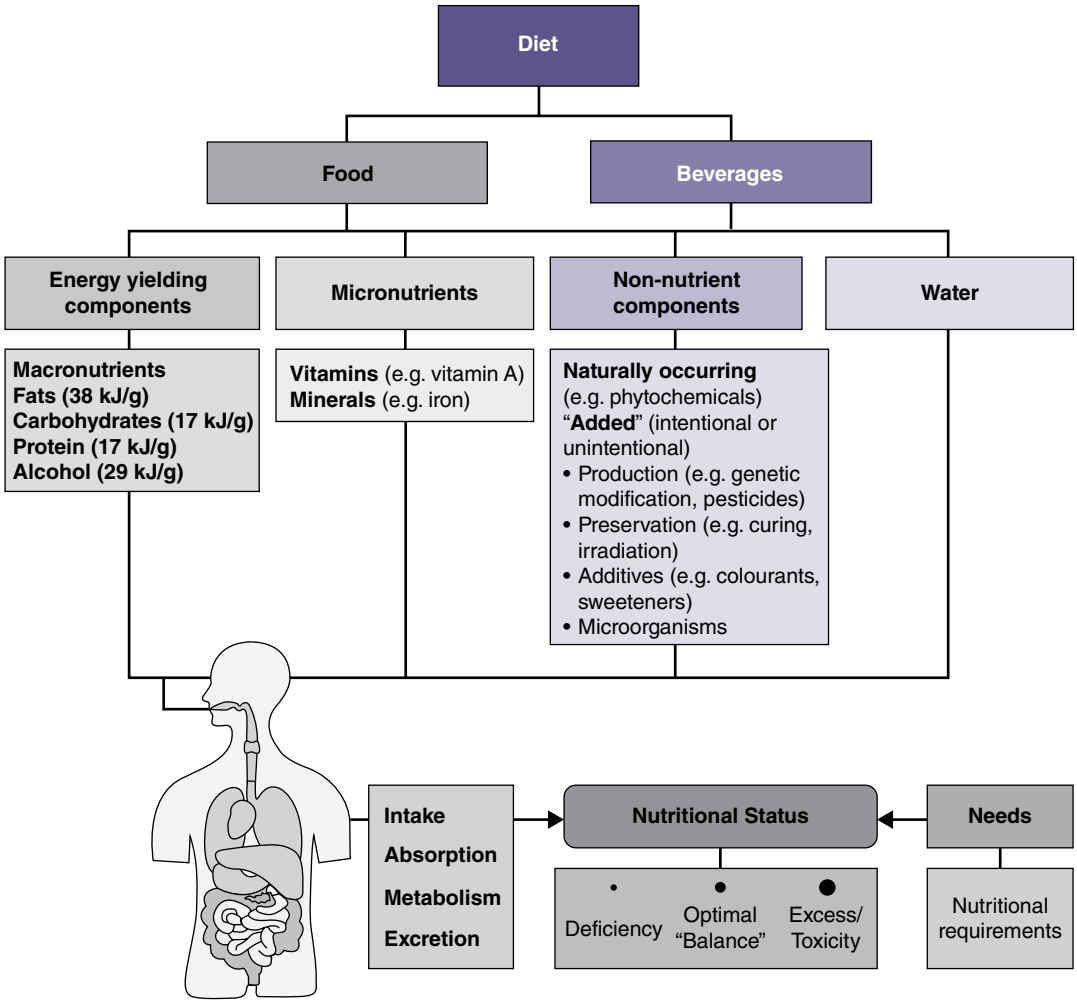

Figure 2.1 The relationship between the components of diet, nutritional requirements and the nutritional status of an individual. Source: Wenhold F.A.M, Faber M. Beverage intake: Nutritional role, challenges, and opportunities for developing countries. In: Grumezesu A.M. (ed). Nutrients in beverages. (Woodhead Publ/Elsvier, Duxford, 2019).

collection but also for the time it takes to review, enter, and analyse the data. It may not always be necessary to obtain detailed data on food intake in order to answer a particular question. When resources are limited it is probably more useful to collect limited data of high quality than to attempt to collect comprehensive dietary data with inadequate resources. Being able to recognise this situation is important for maximising available resources. Table 2.1 lists the different approaches to measurement of food intake that are described in this chapter.

Finally, it is important that the interpretation and application of data derived from dietary intake studies take into account the limitations of the data. This clearly does not improve the quality of the data per se, but maximises their usefulness for the purpose for which they were originally collected. Recognition of the limitations of dietary data involves more than simply stating the limitations. External comparisons to check whether the data are consistent with independent sources of information on food intake and to determine the likely direction and magnitude of any bias are an integral part of the interpretation of dietary data. Relevant sources of comparative information may include food supply and expenditure data and physiological or biochemical measures related to nutrient intake.

Table 2.1 Approaches to the measurement of food intake in population groups, households, and individuals

Type and nature of data	Name of method	Used for describing and/or assessing differences between
Indirect data		
Commodity-level food supply data, e.g., production, imports and exports	Food balance sheets	Countries and regions of the world
Product-level food supply data, e.g., retail and wholesale sales data	Food disappearance data	Country, locality, and season
Household food acquisition and expenditure, e.g., money spent on food	Household consumption and expenditure surveys	Country, locality, season, and type of household
Household food acquisition, e.g., amount of food entering the household	Household food account Household food procurement Household food inventory	Country, locality, season, and type of household
Direct data		
Household food consumption	Household food records	Country, locality, season, and type of household
Qualitative record of foods (but not amounts) eaten over the course of one or more days by individuals	Menu records	Geographical, seasonal, and demographic subgroups and individuals
Quantitative record of food intake, e.g., record of foods eaten over the course of one or more days by individuals	Weighed records and records estimated in household measures	Geographical, seasonal, and demographic subgroups and individuals
Quantitative recall of foods eaten on the previous day, usually obtained from individuals by interview	Single or multiple 24 hour recalls	Geographical, seasonal, and demographic subgroups and individuals (if multiple recalls obtained)
Qualitative, semi-quantitative or quantitative recall, usually of a specified list of foods, eaten in the previous month to year by individuals	Food frequency questionnaires	Geographical, seasonal, and demographic subgroups and individuals
Quantitative recall of habitual intake in the immediate past obtained from individuals by interview	Diet history	Temporal and demographic subgroups and individuals

Source: Adapted from: Gibney, M.J., Lanham-New, S.A., Cassidy, A. *et al. Introduction to Human Nutrition, 2e.* (Wiley Blackwell, Chichester, 2009)

2.2 Indirect measurement of food intake

Indirect measurements of food intake make use of information on the availability of food at national, regional, local or household levels to estimate food intakes, rather than using information obtained directly from the individuals who consume the food. Indirect methods are most useful at population and household levels for determining the amount and types of foods that are:

- available for consumption at national level (commodity-level food supply data).
- traded at wholesale or retail levels (product-level food supply data).
- purchased or otherwise acquired at household level (household acquisition and expenditure data).

Commodity level food supply data

Food supply data are usually produced at national level from compilations of data from multiple sources. The primary sources of data are records of agricultural production and food exports and imports adjusted for changes in stocks and for agricultural and industrial use of food crops and food products. National food supply data are usually referred to as "food balance sheets" or as "apparent consumption" data. Food balance sheets give the total production and utilisation of reported food items and show the sources (production, stocks, and imports) and utilisation (exports, industrial use, wastage, and human consumption) of food items available for human consumption in a country for a given reference period. The amount of each food item is usually expressed per caput (per person)