CHAPTER 01

FOOD AND HEALTH: A BIOLOGICAL PERSPECTIVE

Chapter overview

Chapter objectives

This chapter will enable the reader to:

- Broadly define food and the relationship between food consumption and health
- Describe the ways in which scientific research provides the evidence on effects of food on health
- Appreciate the relative contributions of different scientific disciplines in providing this evidence
- Briefly describe the history of nutrition science and identify emerging areas of knowledge

Key terms

Food
Physiology
Biochemistry
Nutrients
Nutritional balance

Building blocks

Understanding the relationship between food, nutrition and health first requires a 'big picture' of health and where food consumption fits in. One way of doing that is to start with a biological view of health. Even then there are many aspects to understanding how the human body operates and what happens when food is consumed. This introductory chapter provides the overall conceptual framework on how food influences health from a biological perspective, how we know this to be the case, and the directions for building this understanding in the future. Concepts raised here will be expanded on in future chapters.

Introduction

It is common knowledge that **food** is essential for health. Everyone eats food and most people have an opinion on which foods are better for you. So why do we need nutritionists? What's more, why does advice on nutrition always seem to change? The chapters in this book will address these questions from several perspectives.

One short answer to the quandary is that nutrition is both a science and a practice. The World Health Organization (WHO) defines nutrition as 'the intake of food, considered in relation to the body's dietary needs' [1]. As a science it builds a very broad knowledge base from a range of disciplines that practitioners are then able to apply. A great deal of nutrition knowledge comes from the basic sciences such as chemistry, **biochemistry**, biology and **physiology**. Other knowledge comes from health disciplines such as epidemiology, dietetics and medicine, and then from the humanities such as sociology, anthropology and the study of economics.

The unifying factor is the need to better understand the relationship between food and health. Because this is a complex relationship, it needs to be considered from a number of different angles, but they can all come together to represent the science of nutrition.

This book begins by focusing on the biological aspects of nutrition. It starts with a focus on the fundamental building blocks of nutrition science and how this is translated to practice. From these first pieces of information, it becomes apparent that we need to know more all the time to understand the situation better and apply nutrition knowledge more effectively. Knowledge of food and nutrition expands like a network, taking us into different areas and posing more and more questions as we go. You will soon realise why nutrition is constantly debated and why you need to keep abreast of new knowledge to get the most out of it. Enjoy the journey!

Food
substance consumed as part of a meal or snack to provide energy and nutrients for sustaining health; originating from plants or animals and consumed as whole or components thereof with or without processing and blending with other ingredients.

Biochemistry
study of the chemistry of living organisms.

Physiology
study of the vital biological functions of plants and animals.

How does food consumption affect health?

The old adage 'you are what you eat' is perhaps the simplest and best summary of the biological relationship between food and health. When food is eaten it is broken down in the digestive system and most is absorbed as small molecules into the bloodstream. Here it is transported to various parts of the body to serve functions that enable the organism to survive. The implications of this everyday process are enormous. To appreciate this fully, there is a need to understand the structures and functions of the various components of the body (physiology), how these are affected in disease states (pathophysiology), the chemical structure of food molecules (chemistry) and how these play a role in pathways that underlie body function (biochemistry). Part of this may include understanding how the molecules in food influence genetic expression. This is just the start of the biological perspective on nutrition.

There is also a need to understand food itself. Food can be described as a variety of substances consumed to build and maintain the body's structure and function, but food also has its own biological origins as plants and animals. The composition of food reflects its genetic potential [2], nutritional environment and the way in which the food is modified in any shape or form for human consumption. There are parallels to understanding human health in conjunction with the production of food (plants and animals) for human consumption.

Controversy 1.1

Should we rely on food or vitamin supplements for adequate nutrition?

The debate between the relative value of foods versus vitamin supplements can be seen in many forms of media. For example, the headline 'Vitamins can harm cancer patients: scientist' appeared in the *Sydney Morning Herald* on 10 January 2013. This article reported Professor Watson (co-discoverer of DNA) debating in the Royal Society's journal *Open Biology* whether antioxidant use was much more likely to cause than prevent cancer. Supplements of Vitamins A, C and E were implicated, but the Professor was also quoted as referring to consuming blueberries for their taste rather than their health-protecting properties.

In a review of the food versus nutrient debate, Jacobs and colleagues [2] observed that vitamin supplemental trials often drew their logic from observational studies of relationships between food consumption patterns and health, the vitamins in those foods, and the known mechanisms of action of the vitamins. Noting that many of these studies produced unexpected negative health effects from supplementation, they argued that the complex nature of food needs to be better appreciated, and that to promote health it is better to eat food containing a broad range of nurients than supplements, unless there is a clear medical reason.

There is much to disentangle in these commentaries.

- The mechanisms involved relate to cancer and oxidation:
  - antioxidants overcome free radicals that can cause cell damage that leads to cancer in the first place
  - treatments for cancer such as radiotherapy and chemotherapy use free radicals to kill cancer cells
  - antioxidants overcome free radicals, so taking antioxidants may undermine treatment.
- The difference between having cancer and being treated for it, and not having cancer and wishing to support health status.
- The difference between vitamin supplements and the foods from which they have been derived.
- The dual role of food in providing pleasure (taste) as well as nutrition, and the value systems that may influence attitudes towards food because of this.
- The extent of knowledge translation across multiple disciplines that occurs in a single topic on food, nutrition and health.

Given its fundamental role in human existence, the nutritional value of food has a direct impact on the health of the population. This explains why the discipline of nutrition extends to the public health, medicine, social and economic domains [3, 4]. The relationship between food and health goes

beyond simple digestion and absorption of food at the individual level, but it is a good starting point for studying nutrition.

In the last 100 years or so, scientists have identified the chemical composition of critical food components that have proved essential for life. These are referred to as **nutrients**: macronutrients (protein, fat and carbohydrate) and micronutrients (vitamins and minerals). Nutrients are discussed in detail in Chapter 4. While it is now possible to consume nutrients in isolated and supplemental form, it is well to remember that their origins lie in food. Indeed, scientists are continuing to expand their knowledge of nutrients themselves, as well as identifying other components in food that are also proving to be significant (see Chapter 5). While breaking down food into its component parts is informative, in the end we need to put it all back together again to understand the effect of food on health.

The knowledge of nutrients and other components in food does enable us to categorise foods in terms of their common composition. Thus, for example, we associate fruit with vitamin C and dairy foods with protein and calcium (see Chapter 6). However, in classifying foods we should not be limited by our knowledge of single nutrients. By 'thinking foods first' [5], we are able to integrate new knowledge on food components as it emerges and build an understanding of why (and how) a particular food contributes to health. Of course as we do not eat one food alone, we need to view food effects in the context of a total diet.

Thus, the final point on the food–health relationship is the interdependence between foods in promoting health. Foods can also be categorised in terms of their relative position in healthy diets. They are likely to have that position because of their nutrient composition, but this is only part of the story (see Chapter 7). Overall nutrient content is one attribute of a healthy diet, but achieving balance in total energy content and other dietary factors such as salt, sugar and type of fat is also critical in managing the food–health relationship.

nutrients
substances required for the nourishment of the organism, generally provided as components of foods.

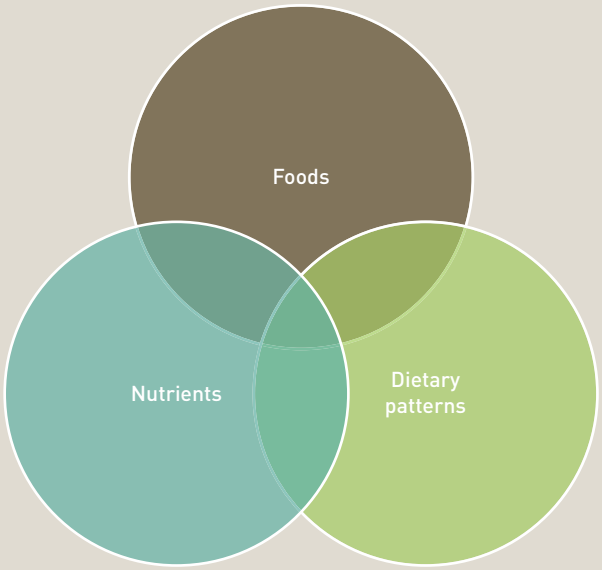


Figure 1.1 Relationship between food, nutrients and whole diets

The concept of balance is critical in nutrition. This relates to the delivery of multiple nutrients as well as the construction of whole diets from different foods. It is consistent with the medical concept of homeostasis—the physiological process by which the internal systems of the body are maintained at equilibrium, despite variations in external conditions [6]. The ensuing chapters in this book expand on the issue of food and **nutritional balance** from a science and practice perspective.

Thus, from a biological perspective, food consumption affects health in the first instance by delivering key nutrients to support and maintain vital systems in the body. Scientific knowledge to date has provided us with a great deal of information for understanding why this is so, but there is always more to know, which means that some of our assumptions may change with time. We do not know everything that is in food and there is more to understand about the functions of the human body, but with ongoing research the picture is becoming clearer, providing stronger evidence for practice.

nutritional balance
meeting the required amounts of all nutrients while at the same time meeting requirements for energy intakes.

Try it yourself

Look for a nutrition article in the general media. How would you evaluate it?

How do we know that food intake affects health?

mechanistic research
explains natural processes in physical or deterministic terms.

There are many ways to establish a position on how food consumption affects health. From the perspective of modern Western science, there is a strong commitment to the scientific method, and then a contribution from a range of scientific disciplines. Evidence frameworks [7] apply a system by which all this information is appropriately assessed to produce a position that is scientifically defensible.

Mechanistic research

Identifying the different chemical compounds in food has been one of the most significant steps in understanding how food affects health. The next step has been to characterise their mode of action in the biological context [8]. This can involve highly controlled experiments that use cell cultures or animal models where a great deal is already known and the pathways under study can be isolated and observed. This form of research can explain how the isolated compounds in food might act on physiological and biochemical processes, and is often referred to as mechanistic research. Given the nature of this research, it is not taken as direct evidence of effects but helps to explain observations that suggest this may be happening. Studying the basic sciences of chemistry, biochemistry and physiology helps the nutritionist to understand what underpins **mechanistic research** and to apply this knowledge appropriately in practice.

Observational studies

Another form of research that builds important knowledge for practice comes from the science of epidemiology. Population health research can provide important observations of relationships between dietary practices and health outcomes. Findings from observational studies still provide indirect evidence, but these studies are stronger than mechanistic research because they are more directly related to the consumption of food and measurements of human health. The study context is less controlled than a laboratory setting, but the discipline of epidemiology exerts its own controls on how the population is sampled, what is measured, and the forms of statistical analyses that are conducted. Understanding these processes enables the nutritionist to evaluate the quality of the research in applying it to practice.

Randomised controlled trials

The best evidence is considered to be provided by randomised controlled trials (RCTs) where people consume foods and health outcomes are measured. Such studies provide direct evidence of effects of food consumption on health. The research is conducted in a more controlled human context, but this in itself creates limitations as people normally eat food in a more flexible environment, and the results may not be very generalisable. Nevertheless, evidence-based methodologies tend to accept that the results provide the highest level of evidence for effects of food on health. The practising nutritionist needs to keep up to date with food-related RCTs, bearing in mind that in most cases there will be studies showing positive effects while others will not.

Food and nutrition facts

The most robust method of determining a cause-and-effect relationship between an intervention (such as food intake) and outcome (such as weight loss) is the randomised controlled trial. The RCT is defined by:

- Randomly allocating participants into different intervention groups
- Including a 'control' or 'comparison' group in order to judge the effects of the intervention

Participants in an RCT should be unaware of the group into which they have been placed, and in an ideal world staff working on the trial should also be blinded to the intervention, but this is not always possible [9].

There are problems in conducting RCTs with food that will be discussed in detail later (see Chapter 14). In reality, positions on the relationship between food and health are based on a body of evidence that is produced from many studies, often of different forms. The end result of all this science may appear to be that nutritionists are constantly changing their minds. This, however, is a simple statement on a complex evolving field.

As the science of nutrition evolves it would be expected that new knowledge would emerge and this may result in a changed recommendation. With the development of a broad framework for understanding nutrition in its own right, however, this is less likely to be problematic. Quality review systems for evidence-based practice in nutrition are now widespread and are used in the development of Dietary Guidelines (Australia: <www.eatforhealth.gov.au>; USA: <http://health.gov/dietaryguidelines>) and other areas of food and nutrition policy around the globe (e.g. <www.aicr.org>). These systems provide methods for searching the scientific literature through to methods for

Table 1.1. Levels of evidence

Level	Intervention	Diagnostic accuracy	Prognosis	Aetiology	Screening Intervention
I	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies
II	A randomised controlled trial	A study of test accuracy with: an independent, blinded comparison with a valid reference standard, among consecutive persons with a defined clinical presentation	A prospective cohort study	A prospective cohort study	A randomised controlled trial
III-1	A pseudorandomised controlled trial (i.e. alternate allocation or some other method)	A study of test accuracy with: an independent, blinded comparison with a valid reference standard, among non-consecutive persons with a defined clinical presentation	All or none	All or none	A pseudorandomised controlled trial (i.e. alternate allocation or some other method)
III-2	A comparative study with concurrent controls: • Non-randomised, experimental trial • Cohort study • Case-control study • Interrupted time series with a control group	A comparison with reference standard that does not meet the criteria required for Level II and III-1 evidence	Analysis of prognostic factors amongst persons in a single arm of a randomised controlled trial	A retrospective cohort study	A comparative study with concurrent controls: • Non-randomised, experimental trial • Cohort study • Case-control study
III-3	A comparative study without concurrent controls: • Historical control study • Two or more single arm study • Interrupted time series without a parallel control group	Diagnostic case-control study	A retrospective cohort study	A case-control study	A comparative study without concurrent controls: • Historical control study • Two or more single arm study
IV	Case series with either post-test or pre-test/post-test outcomes	Study of diagnostic yield (no reference standard)	Case series, or cohort study of persons at different stages of disease	A cross-sectional study or case series	Case series

Source: NHMRC Guideline Assessment Register Consultants (2009). *NHMRC levels of evidence and grades for recommendations for developers of guidelines*. Canberra: NHMRC.

analysing the content of studies, evaluating their quality and arriving at a conclusion on the body of evidence as provided. The practice of evidence-based review is another form of science that is now being taken up and developed substantively in the nutrition domain.

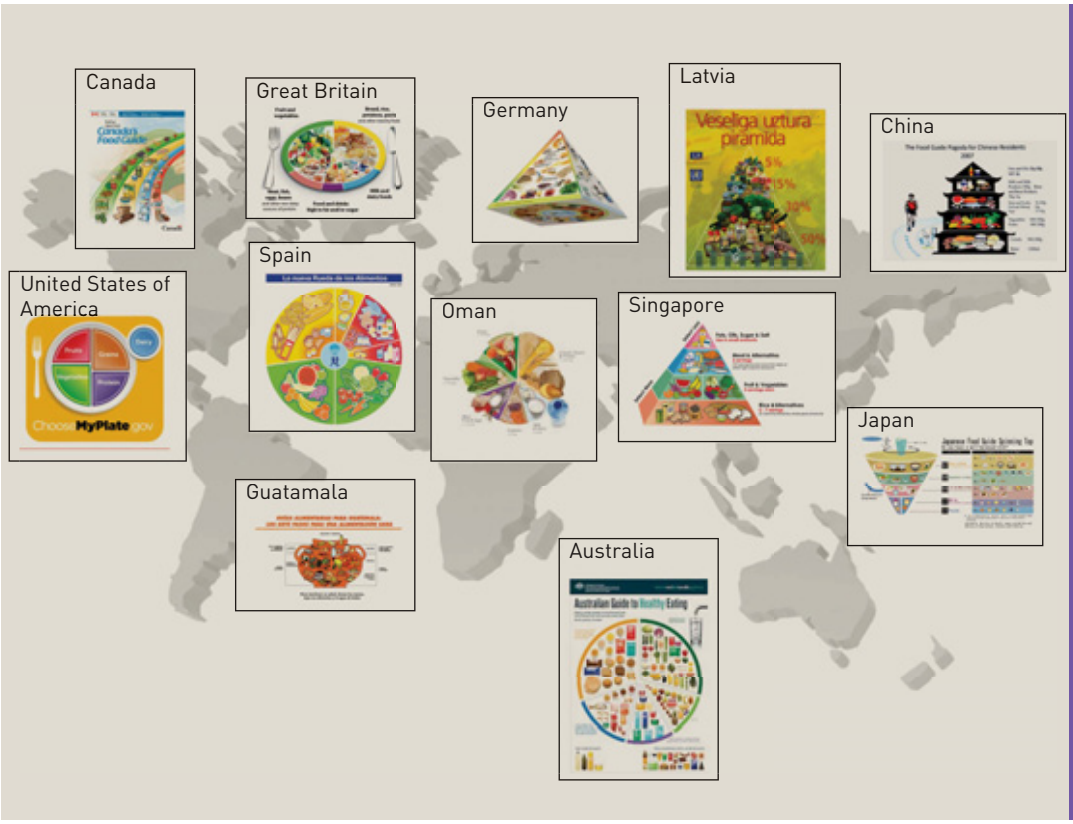


Figure 1.2
World map of food guides

How has the biological understanding of nutrition evolved and where is it headed?

It is difficult to locate the exact origins of modern nutrition science, but it certainly can be seen in a number of settings: from the chemistry laboratories of Wilbur Atwater [10], determining the energy value of foods, to the observations of scurvy prevention with citrus fruits consumption by long-haul mariners [11]. The subsequent isolation and description of vitamin C by chemistry scientists heralded the discovery of vitamins in foods and the development of nutrient reference values [12] for population consumption to protect health. Today the exploration of food composition continues to expand rapidly, particularly with an interest in phytochemicals found in plants that have very intriguing properties [13]. This research has also triggered food innovation, driving the development of foods with improved nutritional qualities that may be linked to better health outcomes.

From the perspective of Western populations, nutrition science developed strongly when the world was at war and food rationing became a major issue [14]. Methods for measuring population eating patterns and observing relationships with health outcomes were developed and led to the first observations of the relationship between diet and the development of cardiovascular disease (CVD). This has now expanded to diet and chronic disease generally, isolating food components and food patterns that may prove deleterious to health when consumed in excess. Food and nutrient-based RCTs have tested a number of hypotheses related to food consumption and health. This research has led to a reconsideration of the emphasis in nutrition on nutrients and other food components rather

than whole foods and whole diets [5]. The emerging concept of food synergy suggests that the sum of the parts may be more effective than the component parts themselves, driving research to consider food and dietary patterns first in addressing the effects of food on health.

Research in practice

The Framingham Heart Study is a longitudinal study that began in Framingham, Massachusetts, USA. Its aim was to investigate common characteristics that contribute to the development of cardiovascular disease (CVD) over a long period of time.

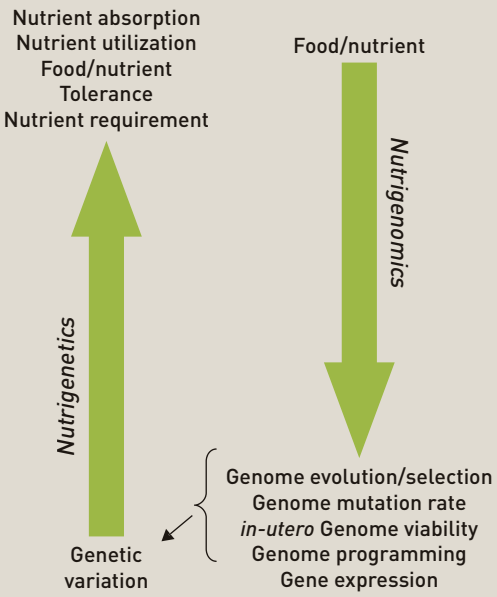
In 1948, 5209 men and women were enrolled in the study and since then have returned for detailed medical examinations every two years. In 1971 a second cohort of 5124 children and spouses of the original cohort were enrolled. In 2002 the third generation (i.e. grandchildren of the original participants) were signed up to join the study.

This study has led to the identification of risk factors and other related medical and psychosocial issues associated with CVD. The study continues today, with research expanding into other areas such as the role genetics have in the development of CVD.

From 1950 to 2011 over 2340 articles have been published using data collected from the Framingham Heart Study [15].

The discovery of the human genome in the 1950s has also produced significant implications for nutrition. Nutritional genomics and nutritional genetics are just some of the new scientific disciplines in the area, showing how the components of foods act as the agents of the environment in what we have come to understand as the important effect of environment on genetic expression. This new development has implications for how much of a nutrient a person may need and how diet may influence whether a person develops a disease state or not [16] (see Chapter 15).

Figure 1.3
Nutrigenetics and nutrigenomics



From the laboratory to the social context, nutrition science has extended its reach to the broader environment. In 2005 the International Union of Nutrition Scientists proclaimed a 'New Nutrition Science' that extended across three arms: the biological, social and environmental [3, 4, 17]. The following chapters in this book reveal the complexity and intrigue that the study of nutrition offers and will continue to offer. Most importantly, they provide a framework for understanding how the knowledge base of nutrition functions, enabling a path towards practice embedded in science while adding strength to the adage 'you are what you eat'.

Review and reflect

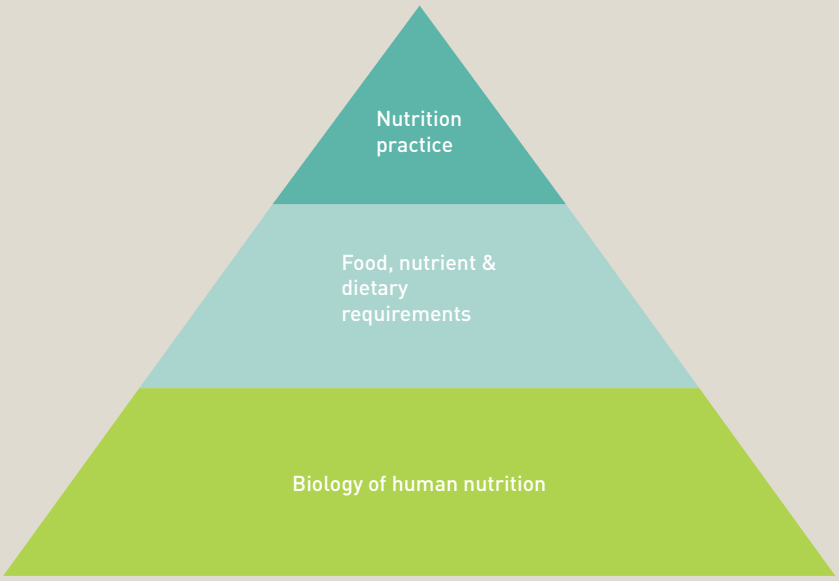
A useful framework for studying nutrition is to consider the building blocks of knowledge in a sequential manner (see Figure 1.4). The foundation lies with basic concepts related to the biology of nutrition. This concerns the nature of food as a source of nutrients and other biological substances that serve particular functions within the body. It extends to the concept of food synergy, where the sum of the parts is greater than the individual components. This leads to the largely observational evidence that dietary patterns are clearly associated with the emergence of lifestyle-related disease.

This knowledge can then be applied to examine the specific needs for nutrients and foods throughout the human lifecycle, and the characteristics of dietary patterns that appear to protect against the development of lifestyle-related disease.

To get to this point, core nutrition methods and standards are applied in practice; they include dietary methodology and nutrient reference values, guidelines and policies. Nutrition practice occurs in various contexts, from an individual making their personal food choices, through to communities, healthcare systems, industry and governments. Thus there are different levels of practice and different pathways for practice. At the most basic level, nutrition practice equates to an individual looking after their health, applying nutrition knowledge to personal food choices. Practices that have an impact on the broader community require specific levels of expertise depending on the context (e.g. in healthcare, industry, research and development or public policy). Regardless of the context, nutrition practice will always be dependent on quality research. This research can occur at any level, from the basic biological underpinnings of nutrition, through to clinical trials on foods and social and environmental research on food systems. By its nature, research will introduce new knowledge. Frameworks for evaluating this research will also be applied, but in the end there may be shifts in recommendations and applications.

Students of nutrition need to have this 'big picture' view of their discipline. As well as having a good grasp of basic concepts, they will also need to appreciate the need to keep up with the scientific literature and maintain strong critical evaluation skills.

Figure 1.4
Relationship between basic biological concepts in nutrition, applications of this knowledge to human health, and practice domains



Summary

- Food delivers essential components that support the structure and function of the human body.
- Balance is a key concept in nutrition and aligns with the principle of homeostasis in the human body.
- Creating balance in dietary intakes requires an understanding of the components of food (nutrients and other substances) and an appreciation of the interdependence between food components and between individual foods and the total diet.
- The concept of food synergy recognises that the effect of food may be greater than the sum of its parts.
- Evidence for the effects of food on health is mounting as the science of nutrition grows and develops across many disciplines.

For further discussion

1. How is food defined and how is it different from vitamin supplements?
2. How does food consumption affect health?
3. How is the relationship between food consumption and health studied?
4. What are some of the scientific disciplines involved in developing the evidence base for effects of food on health, and what kind of information do they provide?
5. What does 'level of evidence' mean?

6. How has modern nutrition science emerged?
7. What are the new areas of knowledge in nutrition that we are likely to see develop in future years?
8. What are the implications for this knowledge in terms of nutrition practices in the future?

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