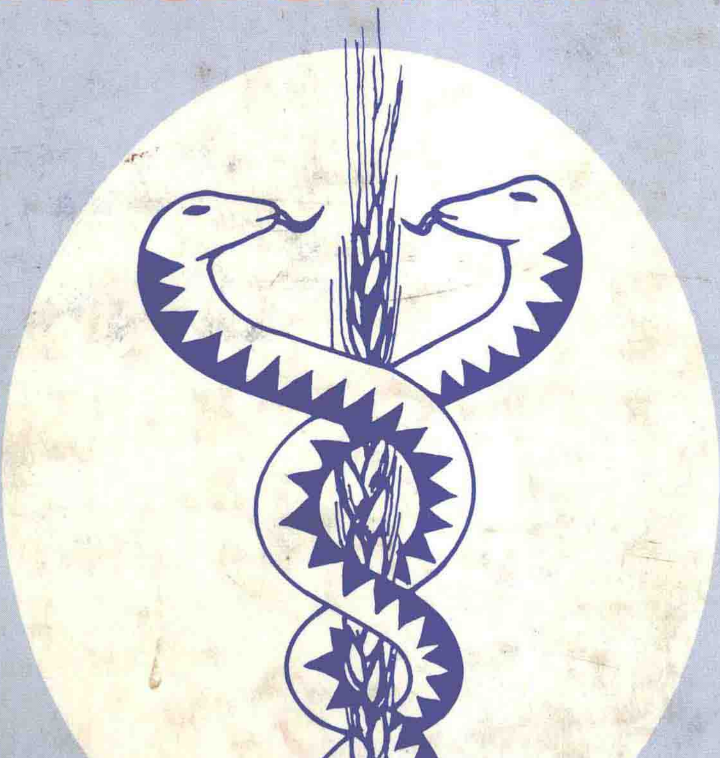
Nutrition for Medical Students



ARNOLD E. BENDER
and DAVID A. BENDER

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Arnold E. Bender

Department of Nutrition,
Queen Elizabeth College,
London

and

David A. Bender

Courtauld Institute of Biochemistry,
The Middlesex Hospital Medical School,
London

175 YEARS OF PUBLISHING
1807 1982

JOHN WILEY & SONS

Chichester · New York · Brisbane · Toronto

British Library Cataloguing in Publication Data:

Bender, A. E.
Nutrition for medical students
1. Nutrition
I. Title II. Bender, D. A.

641.1'24616 TX353
ISBN 0 471 28041 0

Typeset by Computacomp (UK) Ltd.,
Fort William, Scotland

Printed by Vail-Ballou Press,
New York, USA

PREFACE

For many years national and international bodies concerned with health have pressed for the inclusion of nutrition in the medical curriculum. In developed countries good nutrition is regarded as an integral part of preventive medicine yet there is no certainty that undernutrition has been eradicated from all sections of such communities. Moreover, malnutrition is known to play a part in many 'modern' diseases. So far as developing countries are concerned, where malnutrition and undernutrition are obstacles to social and economic development, the problems are obvious.

This textbook is intended to serve as an undergraduate text to help to integrate nutrition with the longer-established medical sciences and it is hoped that it will serve as a useful companion to the handy books of the medical practitioner.

While not holding them responsible for any part of the text of this book we would like to express our sincere thanks to Dr Andrew N. Bamji (The Middlesex Hospital) and Dr John R. Kirwan (The London Hospital), both of whom qualified from The Middlesex, for their constructive criticism of parts of the original manuscript.

Every specialist regards his own subject as being of prime importance and it is not easy to select those areas which are basic and relevant to the study and practice of medicine. In a field that is advancing as rapidly as nutrition and which is reaching into so many areas of human behaviour there will be continuing discussion as to the 'right' parts to include in the medical curriculum. We hope that we have made a reasonable selection.

April 1981

ARNOLD E. BENDER
DAVID A. BENDER

UNITS OF MEASUREMENTS

Despite guide-lines suggested by various international bodies there is no universally accepted system of nomenclature and measurement. Although the International Union for Nutritional Sciences has, for example, agreed that the joule should be adopted as the unit of energy, many authorities retain the calorie. Similarly, although the Food and Agriculture Organisation of the United Nations suggested in 1967 that all vitamins should be measured in micrograms, some authorities retain international units for vitamins A and D. Body weights are quoted in pounds in the United States, in stones and pounds in Great Britain and in kilograms elsewhere. Heights are in feet and inches or metres and centimetres, land area is in acres or hectares.

CONTENTS

CHAPTER 1

INTRODUCTION—THE ROLE OF NUTRITION

Nutrition plays a small part in most medical curricula. Nevertheless, the overriding importance of nutrition to human health has long been recognized by the medical profession.

Records of the cause of death have been kept in Britain since 1838. During that time there has been a marked decrease in deaths from tuberculosis, scarlet fever, measles, diphtheria and intestinal infections—mostly before effective immunization or therapy became available in the 20th century. The reduction in the number of deaths from intestinal infections is largely due to improved hygiene and consequent removal of many of the sources of infection; the reduction in deaths from scarlet fever seems largely to be due to a change in the virulence of the organism; the reduction from other causes, it is suggested by medical historians, is largely due to improved defences because of improved nutrition through the 18th and 19th centuries.

Despite this conclusion, nutrition is largely ignored in the practice of medicine. In 1977 the Lancet carried a report of malnutrition in surgical patients with the sub-title 'An Unrecognized Problem' (Hill *et al*, *Lancet* March 26, 689, 1977). The authors assessed the nutritional status of 105 surgical patients in a major British hospital; their findings generally agreed with a report from the United States that 50% of the surgical patients showed some signs of protein–energy malnutrition—in this book protein–energy malnutrition is discussed as a problem in developing countries, Chapter 14. Sixty per cent of these patients also suffered from vitamin deficiencies.

Of possibly greater import is the statement that in only 22 of the 105 patients studied was there any comment in the case records about their nutritional state. Only 17 had ever been weighed during their stay in hospital, and only 5 had any record of nutritional therapy.

NUTRITION AND MEDICINE

Historically the study of nutrition can be divided into two phases. The first was the discovery of the nutrients required for health and development, so providing the wherewithal for the eradication of deficiency diseases and the provision of diets adequate for the maintenance of good health. The second examined, and continues to examine, the relationships between diet and health in people who are not apparently deficient in any nutrients.

Like medicine, nutrition is an integrated subject built on such basic sciences as chemistry, physics, biochemistry, physiology and microbiology. It relies also on such disciplines as economics and sociology. Broadly, it looks at man and his food supplies from two viewpoints.

Firstly, there is the study of food in relation to man—the examination of aspects of food production, the properties of the various foods, methods of converting raw foodstuffs into a wide variety of edible products, their storage and distribution, their preparation for consumption, and finally their utilization in the body.

Secondly, there is the study of man in relation to his food, seeking to find the influence of social, religious and economic factors on his choice of foods and his eating pattern, which, in turn, may affect his nutritional status and hence his health and well-being.

In the study of nutrition there are obvious interrelationships with medicine, and these are both related to other disciplines as well as with the multitudinous aspects of manufacturing, marketing and industry (Figure 1.1). For example there are clear links between nutrition and food production, whether this is through agriculture, fishing or the factory production of single cell protein, or other novel foods. The nutritionist may need to exert his influence over the types and quality of food produced, as exemplified by high-yielding varieties of cereals that are also richer in protein than older varieties. There may be a need for enrichment of foods with

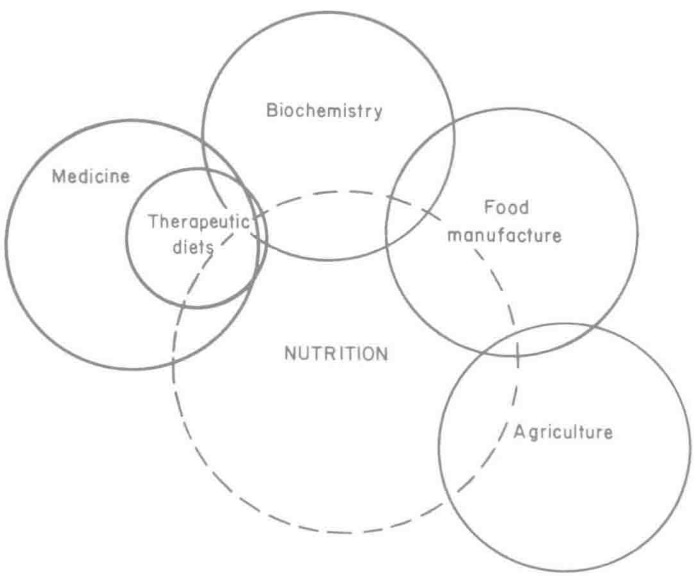

Figure 1.1. Interrelationships between nutrition and other disciplines

nutrients, which will require close collaboration between specialists in health, nutrition and food technology. The safety of food is another area of overlap between these areas.

An example of an unexpected link with medicine, food manufacture and chemistry is in the effect of light on the vitamin, riboflavin: this is destroyed with the formation of a variety of degradation products. The effect has been known for many years to affect milk exposed to sunlight in clear glass bottles, since the degradation products produce an unpleasant flavour and also rapidly destroy the vitamin C present in milk.

It has also been reported that riboflavin added to bread rolls as a nutrient supplement is partially destroyed by exposure to light.

There is a parallel observation in clinical medicine in babies exposed to strong light to destroy bilirubin by photolysis—this is the treatment of kernicterus of the newborn by phototherapy. The treatment results in a fall in the concentration of riboflavin in the tissues and in the plasma. This is only temporary and appears to be harmless, and it is generally recommended that infants undergoing such treatment should not be given extra riboflavin, since its degradation products can have undesirable effects on the photodegradation of DNA.

The three main areas of overlap between medicine and nutrition can be summarized as follows:

(1) Dietary control of disease. Many diseases can be and sometimes have to be treated by dietary modifications, which may, in turn, call for modifications of the foods in manufacture and preparation.

(2) The relation between diet as a possible causative factor in diseases such as coronary heart disease, diabetes, various types of cancer, diseases of the bowel, and, of course, obesity and its sequelae.

(3) The toxicology of natural and processed foods. Many traditional foods contain toxins which have come to light only in recent years; some can be removed by adequate treatment during processing, others may be bred out by the geneticist. The effects on health of industrial pollution of food supplies, residues of insecticides and herbicides and the addition of processing aids or chemical additives are common areas of concern.

To these may be added a fourth broad division we would call 'general information' which covers some of the above and is represented simply by the patient asking his doctor for advice on his food. Is brown bread really better than white? Does intensive rearing of cattle affect the nutritional value of the meat? Do hamburgers and chips constitute an adequate diet for a growing child? Are the advertisements implying that one food is better than another really true? The doctor needs to know the answers to these questions; or at least he must know where to find them. It is the general practitioner who is in contact with members of the public, not the nutritionist or even the hospital dietitian.

CAUSES OF MALNUTRITION

There are many causes of malnutrition not necessarily associated with eating the wrong types of food. Dr Cecily Williams charted these through the problems of inborn errors of metabolism, drug-induced malnutrition and the altered physiology of disease states, to the problems of war, famine and political ineptitude (Figure 1.2). Some of these causes will be examined below.

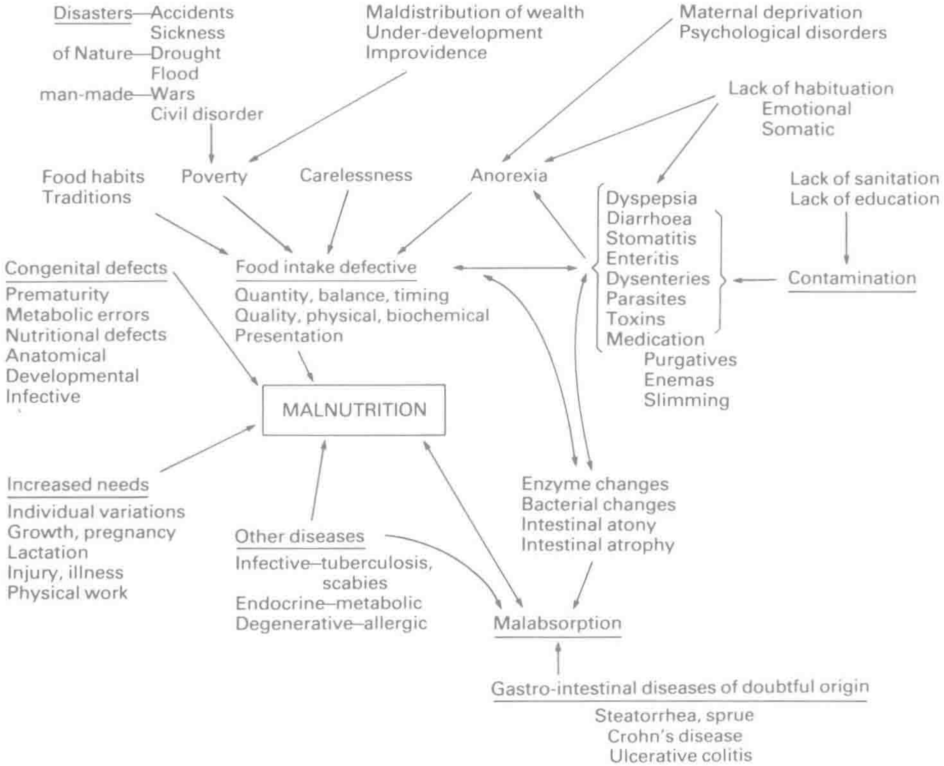

Figure 1.2. Some causes of malnutrition (after C. D. Williams, *Lancet*, 2, 342 (1962))

Difficulties in diagnosis

We often know what nutrients are required, but not always how much. This is partly because of individual variation in needs, partly because of interrelationships between the different nutrients and between nutrients and the environment (including drug treatment) and partly because human beings appear to adapt well to shortages and to changes in intake. Certainly it is possible to diagnose severe deficiencies quite easily—serious shortages of specific nutrients lead to clearly defined disease states such as scurvy, beri-beri or pellagra—but slight, chronic shortages may be difficult or even impossible to diagnose. Even if they lead to ill-health in the long run, the chances are that the marginally deficient individual will eventually succumb to an infection and the underlying malnutrition may never be diagnosed as the cause of death.

The diagnosis of even a relatively severe state of malnutrition requires clinical, biochemical and dietary assessment and examination. Only when all three provide evidence that points in the same direction, and when all three are improved when the missing nutrient is provided is it clear that there was a nutritional deficiency in the first place.

For example, while a deficiency of riboflavin may give rise to a red tongue, a red tongue may itself be due to one of many different causes. Even characteristic clinical signs are not necessarily proof of a clinical deficiency. For example, it is well established that an early sign of vitamin A deficiency is dryness of the bulbar conjunctiva, which becomes thickened, wrinkled and pigmented, but the same effects follow long exposure to glare and dust as well as to an infection, all quite unconnected with diet. The later development of keratomalacia has to be distinguished from other diseases causing corneal lesions, including trauma and infections such as measles and trachoma. Similarly, while some cases of follicular hyperkeratosis appear to be associated with vitamin A deficiency and can be cured with vitamin preparations, the same disorder can arise from dirty skin, exposure to sunlight or deficiency of essential fatty acids or vitamin B_6, and has also been observed in well-nourished subjects.

Biochemical indices of nutritional status are little more use. A difference between the value of a given biochemical variable in the subject under investigation and average for the population as a whole may simply reflect individual variation, and not an abnormality. An individual may not fit the population 'normal', but we do not know what is 'normal' for that person. An 'abnormal' biochemical result may suggest a deficiency state, but is not, of itself, evidence for deficiency in an individual subject.

Dietary intakes are even worse as criteria for nutritional status, since there can be a four or five-fold range in the intakes of apparently normal, healthy individuals. It is reasonable to conclude that if a subject is maintaining constant body weight when consuming only 6 MJ (1500 kcal) per day compared with an average of 10 MJ (and an upper limit of the normal range of 14 MJ), then his need is only 6 MJ and is being satisfied by his diet. However, if his diet has the same composition as the average diet, his intake of all the nutrients will be correspondingly less than the average; we do not know if, when his energy needs are low, his needs for protein, vitamins and minerals are similarly low.

Individual *requirements* for the nutrients range at least two-fold and possibly wider. Recommended intakes are set high enough to cover the needs of those at the upper end of the range. Thus an individual could have an intake only two-thirds or even half the recommended level and still satisfy his needs for the nutrient in question.

Hence the need for three-fold examination—clinical, biochemical and dietary—before any diagnosis of nutritional deficiency can be made. Even then the problems can be almost insoluble. For example, it is well established that the signs of severe shortage of niacin (i.e. pellagra) are mental disturbance, diarrhoea and dermatitis. As one geriatrician asked, 'When so many elderly ladies suffer from forgetfulness, faecal incontinence and scaliness of the legs, are they all short of niacin'? Even if administration of the nutrient does not cure, for example, the skin effects, this might be because the change was irreversible or because advancing years may well mask any nutritional improvement.

Criteria of adequacy

We have to establish criteria of adequacy. For some nutrients a minimum intake has been established, both for experimental and domestic animals and man, which will prevent the appearance or abolish signs of deficiency. At higher intakes a reserve is built up in the tissues, and at still higher intakes various coenzymes reach their maximum saturation level. Ultimately a level is reached at which the tissues of the body become saturated with the nutrient so that any excess, at least of the water-soluble nutrients, is excreted.

The definition of an adequate diet is one that will provide full stores of all the materials required for growth and repair of tissues and so provide 'good health'.

If the intake of one or more nutrients falls below this level, which may differ for different individuals, the first development will be a gradual reduction in body stores, which will continue until they are exhausted. This would have no effect on health and can be revealed only by examination of the blood and tissues—biochemical assessment of nutritional status.

Dietary measurement	*Biochemical assessment*	*Clinical examination*
Adequate diet	Full body stores	Good health
↓	↓	↓
Reduced diet	Reduced stores	Good health
↓	↓	↓
Inadequate diet	No stores	

Continued deficiency will then begin to impair the normal functioning of the organs and tissues—as shown biochemically—but there may be no visible signs of ill-health. This condition is termed 'subclinical malnutrition'.

Dietary measurement	*Biochemical assessment*	*Clinical examination*
Adequate diet	Full body stores	Good health
↓	↓	↓
Reduced diet	Reduced stores	Good health
↓	↓	│
Inadequate diet	No stores	??? │
↓	↓	│
	Impairment of function	??? ↓

It is only when the shortage of the nutrient has become sufficiently severe to damage the tissues and organs that this becomes apparent and clinical signs develop.

Dietary measurement	*Biochemical assessment*	*Clinical examination*
Adequate diet	Full body stores	Good health
↓	↓	↓
Reduced diet	Reduced stores	Good health
↓	↓	│
Inadequate diet	No stores	??? │
↓	↓	│
	Impairment of function	??? ↓
	Damage to tissues and organs	Clinical signs of disease
	↓	↓
	Irreversible damage	Severe clinical signs
		↓
		Death

In addition to the vague area of subclinical malnutrition there is another area defined as covert malnutrition. The individual is perfectly well, despite a low intake of the nutrient, until he is stressed and then his needs are greater and deficiency manifests itself.

The best known example is that of vitamin C. An intake of 5–10 mg per day is sufficient to prevent or cure the clinical signs of scurvy, but 20 mg are needed for proper healing of wounds. So the subject would be 'adequately' provided with vitamin C at 10 mg per day until the stress of wounding was encountered, when this intake would be inadequate.

It was reported that the number of cases of xerophthalmia admitted to a hospital in Bengal rose seasonally to coincide with the increased availability of food from the recently harvested rice crop. When the diet was too poor to allow growth, xerophthalmia did not manifest itself despite the low intake of vitamin A; when more food was available so that there was sufficient energy and protein to permit growth, the signs of vitamin A deficiency appeared.

A parallel example was observed in a laboratory experiment. We found no detectable difference between adult animals fed at 5% and 10% protein by all the criteria available. However, when the animals were dosed with an anaesthetic, those fed on 5% protein slept longer and some died sooner than those fed on 10% protein. They were unable to cope with the metabolic stress of detoxifying the anaesthetic.

Recommended daily amounts (RDA)

As is described later, figures for the amounts of nutrients that 'should' be ingested daily have been established for population groups. These are calculated from the measured requirements of a limited number of subjects in such a way as to satisfy the requirements of those who have needs well above the average. The problem in satisfying the needs of an individual is that there is a wide range of variation, and this, added to the difficulties of assessing nutritional status of an individual, makes it extremely difficult to define the adequate diet. The only way to guarantee an adequate intake is to ensure that each individual ingests (and absorbs) the RDA, since this amount will satisfy the needs of those at the highest end of the scale.

When a large group of the population is ingesting less than RDA then it is possible that some are not getting enough, but when an individual is not ingesting that amount he could still be satisfying his individual needs.

Even for population groups there is a difference between the early warning stage—relatively low intake—and the serious public health problem when clinical signs have appeared. An example of this is provided by the guide-lines proposed by the International Vitamin A Consultative Group, which are described more fully under Xerophthalmia.

These guide-lines suggest that when the objective is to improve the general vitamin A status of a population, then biochemical variables (in this case plasma vitamin A levels of less than 100 μg/litre) or mild clinical signs are sufficient evidence. When the objective is the control and prevention of xerophthalmia and its blinding sequelae, then the more severe clinical signs are the variables to be measured.

In western countries, Governments can afford to take all measures to attempt to guarantee good nutrition, even to the extent of enriching foods with added nutrients when there is no clear evidence of need (see Chapter 19). On the other hand, in poorer developing countries, governments can only afford to attempt to eradicate disabling disease states.

DIETARY EXCESS OR BALANCE

So far we have discussed old-fashioned nutrition—are people getting enough?—which may even be considered the simple part of the subject. The modern problem is to ascertain whether or not nutrition is involved in multifactorial diseases such as coronary heart disease and cancer, and if so, which foods or nutrients are important.

The term 'balanced diet' is commonly used simply to describe an adequate diet. It is more correctly applied to a diet containing the correct ratios of nutrients, since excessive intakes of many nutrients are harmful and even excessive intakes of foods such as fats and sugars and total energy have been blamed for many of the disorders of 'well-fed' communities of the world.

FURTHER READING

Butterworth, C. E., and Blackburn, G. L. (1975). Hospital Malnutrition. *Nutrition Today*, **10,** 8.

Frankle, R. T. (1976). Nutrition education for medical students. 1. What is it? Where has it been? Why should it be taught? *J. Amer. Dietet. Assoc.*, **68,** 513.

Symposium: Nutrition in hospitals (1978). *Proc. Nutr. Soc.*, **37,** 65 *et seq.*

WHO (1976). *Nutrition in Preventive Medicine.* WHO, Geneva.

Young, E. A., and Weser, E. (1975). Integration of nutrition in medical education. *J. Nutr. Ed.*, **7,** 112.

MAJOR TEXTBOOKS OF NUTRITION

Briggs, G. M., and Calloway, D. H. (1979). *Bogert's Nutrition and Physical Fitness.* W. B. Saunders Co., Philadelphia.

Davidson, S., Passmore, R., Brock, J. F., and Truswell, A. S. (1979). *Human Nutrition and Dietetics.* Churchill-Livingstone, Edinburgh.

Krause, M. V., and Mahan, L. K. (1979). *Food, Nutrition and Diet Therapy.* W. B. Saunders Co., Philadelphia.

McCollum, E. V. (1957). *A History of Nutrition.* (Chapters 14–20, 27). Houghton Mifflin Co., Boston.

CHAPTER 2

RECOMMENDED DAILY AMOUNTS

Some of the problems involved in arriving at figures for quantities of nutrients that 'should' be consumed are reflected in the terms used by different authorities—recommended daily intakes (RDI), or allowances or amounts (RDA)—the term used in each case being the result of much discussion and not merely a method of expression adopted as a mere whim.

It is obviously essential to know how much of each nutrient should be consumed, but we have to define our objectives. What are the criteria of adequacy—maximum rates of growth in the young, prevention of deficiency diseases in young and adults alike, saturation of enzymes with their cofactors, building up reserves of nutrients in the body (and if so, how large

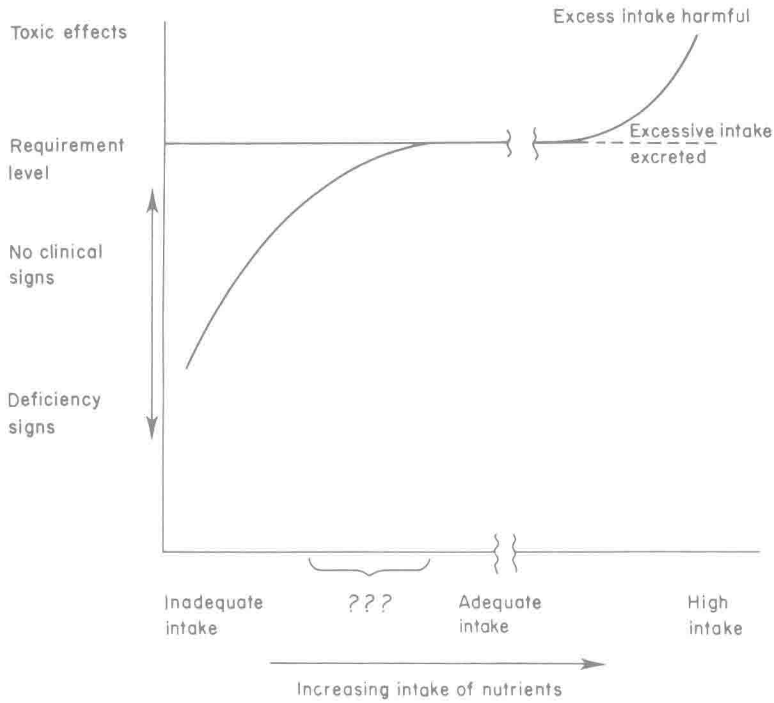

Figure 2.1. Dose-response curve for nutrients. Water-soluble vitamins and many minerals are excreted when ingested in excess. Vitamins A and D are toxic in excess; some minerals which are essential in small amounts are toxic in larger amounts

should these reserves be?), or just that undefinable objective, the maintenance of good health?

Vitamin C serves as an example of how these different criteria can affect the levels of intake that we recommend. It is possible to prevent or cure the vitamin C deficiency disease, scurvy, with between 5 and 10 mg of the vitamin per day. However, at this level of intake, the healing of wounds is slow; 20 mg per day are required for optimum wound healing. Similarly, 390 μg per day of vitamin A will prevent or cure the eye signs of deficiency, but 750 μg per day are required to build up stores in the liver considered 'normal'.

Figure 2.1 illustrates the problem graphically. At low levels of intake of any specific nutrient, there will be clinical signs of deficiency. These will disappear as the intake of the nutrient is increased. The curve relating nutrient intake and disappearance of clinical signs rises more and more slowly, so that the end point, what we might call an optimum or adequate level of intake, is very difficult to establish.

At intakes greatly in excess of requirements, vitamins A and D are toxic, since there is no mechanism for excretion of any surplus in the urine, as there is for the water-soluble vitamins. With many of the essential minerals, the difference between an intake adequate to satisfy nutritional requirements and the intake that is chronically, or even acutely, toxic, is small. As discussed in Chapter 16, this may mean that foods grown in regions where the soil content of a mineral salt is very high can contain toxic amounts of the mineral, even when eaten in moderate amounts.

Figure 2.2 illustrates the different possible criteria that may be used to assess the adequacy of nutrient intakes, such as: (*a*) the disappearance of clinical signs and symptoms, although there may still be biochemical abnormalities (subclinical malnutrition), or covert malnutrition, which is not revealed until the subject comes under some kind of stress; (*b*) the normalization of biochemical systems and responses, or the saturation of enzymes with their cofactor; (*c*) the provision of reserves in the tissues; and (*d*) the saturation of the tissues with the nutrient, so that any excess is excreted in the urine, either unchanged or as a metabolite.

The criteria adopted may vary with different nutrients, and occasionally with the opinions of different authorities, so that tables of recommendations produced in different countries may differ from one another to some extent, as discussed below.

For example, the recommended intake of proteins is that required to replace obligatory losses, plus the additional amount that is required to maintain nitrogen balance, as discussed in Chapter 5. The recommended intake of vitamin A is not just the amount needed to prevent the development of eye signs, 390 μg per day, but also enough to permit storage in the liver, giving a total of 750 μg per day. The recommended intake of

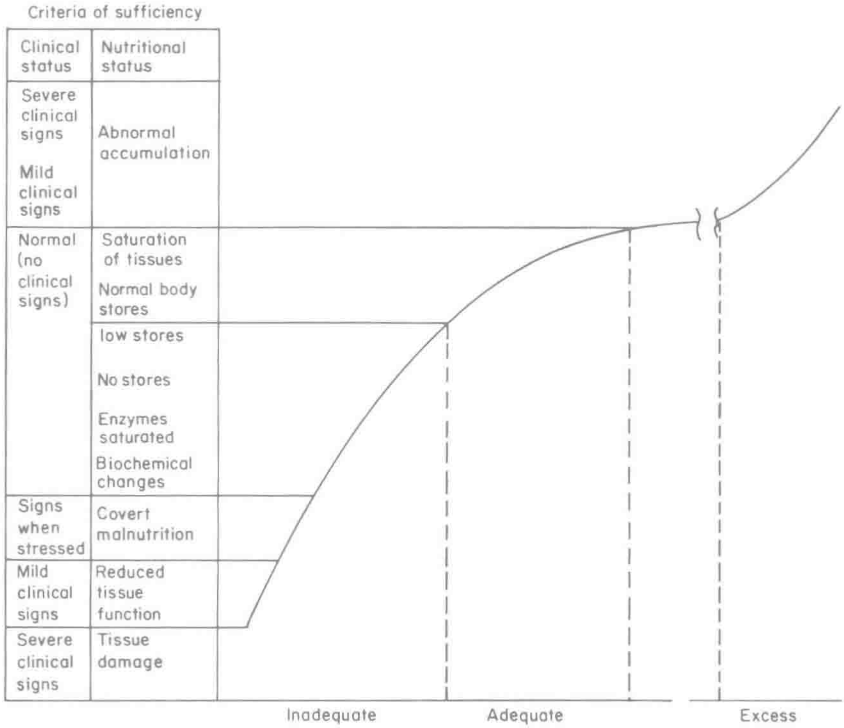

Figure 2.2. Dose–response to nutrients, graduated as to criteria of sufficiency

thiamin is that amount needed to prevent the development of beri-beri, the thiamin deficiency disease, plus an increment to meet the needs of those with higher than average requirements.

Variation between individuals presents a major problem. There have been few measurements of human requirements; those that have been made indicate that there is a distribution of requirements of the form shown in Figure 2.3—the normal distribution curve, which is typical of many biological measurements.

With such a distribution curve, 95% of the area under the curve falls within 2 standard deviations (*SD*) of the mean, as shown in Figure 2.3. This means that if the whole population group were to consume an amount of nutrient equal to the measured average requirement plus 2 *SD*, then the theoretical requirements of 97.5% of the population will be taken care of. For this reason, recommended daily intakes are generally calculated on the basis of mean (average) requirement plus 2 standard deviations. This assumes that the distribution curve is normal (Gaussian) and the evidence for this is based on a limited number of measurements.