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Assessment of Protein Requirements by Nitrogen Balance

By D. S. MILLER (*Queen Elizabeth College, London W.8*) and P. R. PAYNE (*London School of Hygiene and Tropical Medicine, London W.C.1*)

During the last 100 years, published estimates of the requirements of adult man for protein have fallen from 120 g./day to around 30 g./day. Early estimates were intended, for example by Voit, to be used as dietary standards for workers and were based on recorded intakes of labourers. However, the tradition soon arose that liberal allowances of protein in the diet were essential for the maintenance of mental and bodily vigour, and as a protection against disease. Subsequent research has failed to establish the need for protein over and above that necessary to replace inevitable losses from the tissues and to provide for growth, and thus the criterion of nitrogen balance has come to be generally adopted as an indication of dietary adequacy.

A factorial method for calculating protein requirements will be described. An addition is made of the losses of nitrogen from the body by all routes including urine, faeces, skin, and where appropriate the products of conception, and milk. To these are added calculated nitrogen gains during growth. Allowance can be made for possible variations between individuals, to provide a total nitrogen requirement that can be expressed in terms of an ideal perfectly utilized protein.

Our understanding of the dependence of protein quality on amino acid composition now has a quantitative basis, and other factors that influence the utilization of dietary proteins have been studied and evaluated. In particular the interrelationship

between energy and protein metabolism will be examined in view of its importance to the world food problem.

The utilizable protein content of diets can be estimated, and evidence will be presented that man can survive in apparent good health on diets that provide sufficient to meet his estimated needs for nitrogen balance. No claim is made that such diets are culturally acceptable or that higher levels of protein are necessarily detrimental; merely that they confer no known benefit.

During the next 30 years the world's population will double and so will mankind's total nutrient requirements. The lowered estimates for protein allowances do not in any way diminish the magnitude of the task of meeting this growing demand, nor do they represent a lowering of dietary standards, but they should be seen as directing our efforts towards the production of more palatable foods of all kinds rather than searching for some apparently easier solution to the problem by increasing the supply of specific nutrients such as protein.

Protein Nutrition and Enzymes

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In this paper we deal mainly with studies that have been made in man, because this Symposium is concerned with human protein nutrition.

One way of looking at the relationship between protein nutrition and enzyme activity is to regard enzymes as proteins whose specific enzymic activity serves as a natural label or marker. It is not, of course, strictly accurate to equate the activity of an enzyme with its amount. The two things may well be different *in vivo*, but when assays are made *in vitro*, under so-called optimum conditions, it is probably reasonable to take activity as a measure of amount.

In studies on human subjects measurements have most often been made on serum or plasma for obvious practical reasons. Enzymes that are found in the plasma must have been synthesized elsewhere; sometimes they are specific for a particular organ or tissue. Examples of plasma enzymes that are decreased in malnutrition with their probable tissues of origin are pseudocholinesterase (acylcholine acyl-hydrolase, EC 3.1.1.8) (liver), alkaline phosphatase (orthophosphoric monoester hydrolase, EC 3.1.3.1) (bone), amylase and lipase (pancreas) (Waterlow, 1969).

In theory a fall in the amount of a circulating enzyme, as measured by its activity, could result