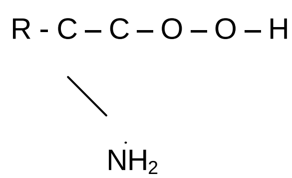
Chapter 3: Protein – The “First” Nutrient

The word “protein” originates from the idea that proteins are central to life and the first nutrient. Vitamins (“vita” meaning life and “amin” meaning protein) got their name from the misimpression that amino acids, the building blocks of protein, were the essential components for maintaining life. Maintaining the amounts of protein in muscles and organs is indeed essential to life and the main objective of the adaptation to starvation. In fact, loss of 50 percent of body protein is generally accepted as being incompatible with life.

Proteins are found in both animal and plant foods, but the mixture of amino acids, the building blocks of the protein, found from different sources varies. As a result, there are 21 common (nonessential) amino acids and nine essential amino acids. Essential amino acids are those that cannot be synthesized from other amino acids, but must be consumed in the diet. The usual way that nonessential amino acids are formed is by metabolism of other amino acids. All amino acids have a basic structure of an alpha-amino nitrogen and carboxylic acid. What defines their identity is the side chain denoted as R in the diagram below:



Some amino acids are called conditionally essential, because they must be consumed in the diet during growth to provide adequate growth rates, but become nonessential in adults who are not growing. One such amino acid is histidine, which is essential for growing rats but not adult rats. Much of the data on essentiality of amino acids is obtained in rats, where single amino acid elimination is a way of determining whether a given amino acid is essential. For example, lysine and threonine cannot be made from other amino acids by transamination and must be included in the diet.

Essential Amino Acids

Histidine

Isoleucine

Leucine

Lysine

Methionine

Phenylalanine

Threonine

Tryptophan

Valine

Nonesssential Amino Acids

Alanine

Arginine

Asparagine

Aspartic Acid

Cysteine

Glytamic Acid

Glutamine

Glycine

Proline

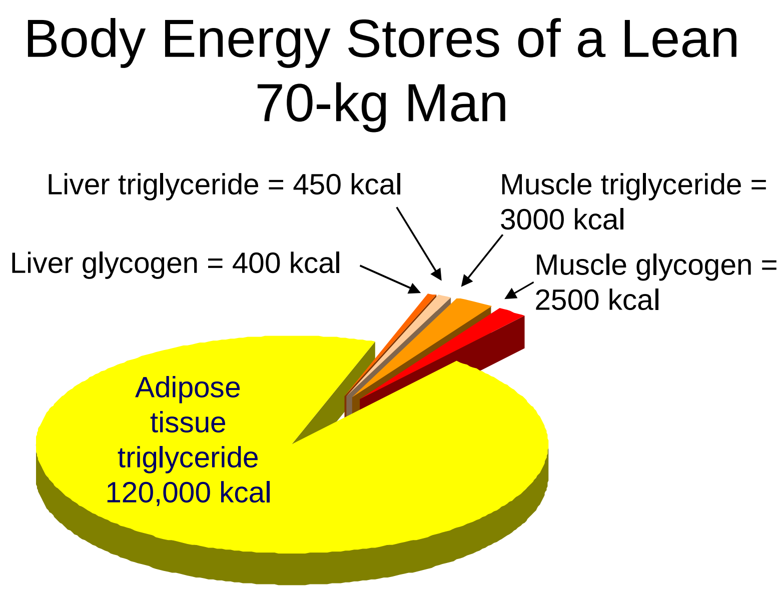
Serine

Taurine

Tyrosine

Protein Stores and Survival

Mankind is very well adapted to malnutrition and starvation, and this adaptation is reflected both in the way the body stores energy and how it uses these stores of energy when food intake is reduced or eliminated altogether. In the average 70 kg man, the largest store of calories is in the form of fat in adipose tissue with approximately 135,000 calories stored 13.5 kg of adipose tissue. This storage compartment can be greatly expanded with long-term overnutrition in obese individuals. There are approximately 54,000 Calories stored as protein both in muscle and viscera. Only half of these calories can be mobilized for energy, since loss of 50 percent of body protein stores is generally accepted to be incompatible with life. In addition to being an energy source, protein plays a functional role in many organs, including the liver, and depletion is associated with impaired immunity to infection. In fact, the most common cause of death in an epidemic of starvation is typically simple bacterial pneumonia. Conservation of protein is an adaptation tightly linked to survival during acute starvation.



Protein Supplementation for Weight Management

The mechanisms contributing to obesity are complex and involve the interplay of behavioral components with hormonal, genetic and metabolic processes (1–3). There is evidence that modestly increasing the proportion of protein in the diet, while controlling total energy intake, may improve body composition, facilitate fat loss and improve body weight maintenance after weight loss (3–6). A number of recent studies have also demonstrated that a diet with a lower proportion of carbohydrate improves glycemic control in both healthy individuals and type 2 diabetic patients and can lead to improvements in fasting triacylglycerols, HDL cholesterol and the total cholesterol-to-HDL ratio over a 6 to 12 month period (7, 8). However, weight loss and maintenance are possible with either a low- or high-carbohydrate diet. Prior data from the Weight Control Registry suggested that among the common features of patients who successfully maintained long-term weight loss was the adoption of a low-fat, high-carbohydrate diet (9). More recent data indicate that diets with moderate fat content may also be effective (10). Nevertheless, positive outcomes associated with increased dietary protein are thought to be due primarily to lower energy intake associated with increased satiety (8, 11–13), reduced energy efficiency and/or increased thermogenesis (14–16), positive effects on body composition, specifically lean muscle mass (4, 17, 18), and enhanced glycemic control (18, 19).

It is well established that under most conditions, protein is more satiating than the isoenergetic ingestion of carbohydrate or fat (8, 11–13). This suggests that a modest increase in protein, at the expense of the other macronutrients, may promote satiety and facilitate weight loss through reduced energy consumption (20). The increased satiety from protein has been observed in a single meal (21, 22) and over 24 hours (23). In one short-term study, satiety and metabolic rate were examined over a 24-hour period in a respiration chamber. Throughout the day, satiety was greater in the high-protein group (protein/carbohydrate/fat: 30/60/10 percent energy) compared with the high-fat group (protein/carbohydrate/fat: 10/30/60 percent energy). Importantly, this effect was noted during postprandial periods as well as during meals (12).

The negative energy balance produced by higher-protein diets is probably due to a lower spontaneous energy intake brought about by enhanced satiety (11–13) and a greater thermogenic effect (14–16). This ability of a moderately higher-protein diet to limit weight regain after weight loss is ultimately the key determinant of efficacy. In a study of 113 moderately overweight men and women who lost 5 to 10 percent of their body weight during a 4-week very low-energy diet, those who consumed 18 percent of their energy intake as protein (101.7 g/d) during a 6-month weight-management phase regained less weight than subjects who consumed 15 percent of their energy intake as protein (82.7 g/d) (17). Despite only a 3 percent difference in protein-derived energy, the researchers noted that this effect was independent of changes in cognitive restraint, physical activity, resting or total energy expenditure, and hunger scores, as none of these parameters differed between groups.

Despite some evidence that habitual exposure to a higher-protein diet may diminish its effect on satiety (24), others have suggested that the greater satiating effects of a higher-protein diet are relatively long lasting (25–27). In a 16-week study, subjects consuming a high-protein (34 percent)/lower-fat (29 percent) diet reported greater post-meal satiety than subjects consuming a standard protein (18 percent)/higher-fat (45 percent) diet (27).

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