Proteins

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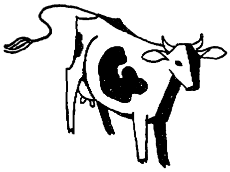

YOU are looking at a superb package of proteins when you see yourself in a mirror. All that shows—muscles, skin, hair, nails, eyes—are protein tissues. Teeth contain a little protein.

Most of what you do not see is protein, too—blood and lymph, heart and lungs, tendons and ligaments, brain and nerves, and all the rest of you.

Genes, those mysterious controllers of heredity, are a particular kind of protein.

Hormones, the chemical regulators of body processes, and enzymes, the sparkplugs of chemical reactions, also are proteins.

Life requires protein. A Dutch physician turned chemist, Gerrit Jan Mulder, first observed this fact, which we now take for granted. He announced in 1838 his conclusion from many investigations that all living plants and animals contain a certain substance without which life is impossible. He did not know what was in it, but he was sure it was vital. He named it protein, from a Greek word meaning first place.

Scientists since then have discovered that there are hundreds of different kinds of protein—not just the one substance Mulder observed. They also learned that proteins are unique in that they contain the element nitrogen. All our foodstuffs—fats, starches, sugars, and proteins—contain the elements carbon, hydrogen, and oxygen in varying proportions. Because proteins contain them and also nitrogen, they have a special importance and power.

Proteins have to be made by living cells. Proteins do not exist in air, like nitrogen or oxygen. They do not come directly from the sun, like energy.

Most plants make their own protein by combining the nitrogen from nitrogen-containing materials in the soil with carbon dioxide from the air and with water. The energy they need for the process comes from the sun. Legumes, which include beans, peas, and peanuts, can use the nitrogen directly from the air for combining with the other substances to make protein.

Animals and people cannot use such simple raw materials for building the proteins. We must get our proteins from plants and other animals. Once eaten, these proteins are digested into smaller units and rearranged to form the many special and distinct proteins we need.

Although we sometimes hear plant proteins referred to as "inferior" to animal proteins, plants are the basic factory of proteins. All proteins come directly or indirectly from plants.

We depend heavily on farm animals to convert plant proteins into animal proteins for us, but most animals, too, must have some animal protein supplied to them. The ruminant animals—cattle, sheep, goats—are an exception, because they can use the simple nitrogen-containing substance in young pasture grasses; the micro-organisms in their paunches can make microbial proteins, which the animal can then digest and use.

NEXT TO WATER, protein is the most plentiful substance in the body. If all the water were squeezed out of you, about half your dry weight would be protein. About a third of the protein is in the muscle. About a fifth is in the bone and cartilage. About a tenth is in the skin. The rest is in the other tissues and body fluids. Bile and urine are the only fluids that do not contain protein.

There are several dozen proteins in the blood alone.

One of the busiest is hemoglobin, which constantly transports oxygen from the lungs to the tissues and brings carbon dioxide back from the tissues to the lungs. Ninety-five percent of the hemoglobin molecule is protein. The other 5 percent is the portion that contains the iron.

Other proteins in the blood are defenders, for they give us the means of developing resistance and sometimes immunity to disease.

Gamma globulin can also form antibodies, substances that can neutralize bacteria and viruses and other micro-organisms. Different antibodies are specific for different diseases.

Once we have had a disease, like measles, and the antibody for measles has been formed, it stays in the blood, and we are not likely to have measles again. A vaccination, such as for poliomyelitis, introduces a tiny amount of the inactive or dead virus into the body to stimulate the blood to form the specific antibody needed for neutralizing the virus that causes poliomyelitis. The presence of an antibody in the blood may give the person immunity to the disease. At least it gives him a head start in fighting the virus, and the disease will be less severe.

Gamma globulin also helps the scavenger cells—phagocytes—engulf disease microbes.

Proteins help in the exchange of nutrients between cells and the intercellular fluids and between tissues and blood and lymph. When one has too little protein, the fluid balance of the body is upset, so that the tissues hold abnormal amounts of liquid and become swollen.

The proteins in the body tissues are not there as fixed, unchanging substances deposited for a lifetime of use. They are in a constant state of exchange. Some molecules or parts of molecules always are breaking down and others are being built as replacements. This exchange is a basic characteristic of living things; in the body it is referred to as the dynamic state of body constituents—the opposite of a static or fixed state. This constant turnover explains why our diet must supply adequate protein daily even when we no longer need it for growth. The turnover of protein is faster within the cells of a tissue (intracellular) than in the substance between the cells (intercellular).

Proteins, like starches, sugars, and fats, can supply energy.

One gram of protein will yield about 4 Calories when it is combined with oxygen in the body. One ounce will give 115 Calories. That is about the same amount as starches and sugars give.

The body puts its need for energy above every other need. It will ignore the special functions of protein if it needs energy and no other source is available. This applies to protein coming into the body in food and to protein being withdrawn from the tissues. Either kind gets whisked through the liver to rid it of its nitrogen and then is oxidized for energy without having a chance to do any of the jobs it is especially designed to do. The protein-sparing action of carbohydrates means that starches and sugars, by supplying energy, conserve protein for its special functions.

WE CANNOT TALK about proteins very long without getting into the subject of the amino acids, the chemical units of which proteins are made. I discuss them in the next chapter, but I must point out here that the kinds and amounts of amino acids in a protein determine its nutritive—or biological—value.

The amino acid composition of animal muscle, milk, and egg is similar, though not identical, to the amino acid composition of human tissues. Because these animal proteins can supply all of the amino acids in about the same proportions in which they are needed by the body, they are rated as having a high nutritive value.

The proteins from fruits, vegetables, grains, and nuts supply important amounts of many amino acids, but they do not supply as good an assortment as animal proteins do. Their nutritive value therefore is lower. The proteins from some of the legumes—especially soybeans and chickpeas—are almost as good as those from animal sources.

To have the nutritive value of the mixture of proteins in our diets rate high requires only that a portion of the protein come from animal sources.

TO STUDY THE NEEDS of people and animals for proteins, scientists commonly study the nitrogen balance.

Nitrogen is easier to measure than protein. The amount of nitrogen, properly determined, is an accurate index of the amount of protein involved. Because the common proteins average 16 percent nitrogen, we can measure the amount of nitrogen in a food, multiply the amount by 6.25, and get our answer in grams of protein.

A nitrogen-balance study is based on the principle that if we know the amount of nitrogen that goes into the body in the food and the amount that leaves the body in the excreta, we can calculate what has been used. The amount that has been used reflects the amount that has been needed.

The body constantly uses materials for maintenance, regardless of the supply. It operates best when the supply of materials from food is generous and regular, but it does not stop functioning immediately when the food fails to supply what is needed. It mobilizes material from its tissues to meet these needs as long as that supply will last.

Suppose that the diet does not furnish enough protein for the body's daily operating and repair needs. The first thing the body does is to draw on some of its own tissue protein to supply this daily wear-and-tear quota. As a result, the operating and repair needs are met, and the normal kind and amount of end products of protein metabolism leave the body.

In a balance study, each person's food intake is weighed. Samples of the food are analyzed for nitrogen. Then the output, the urine and feces, is collected and analyzed. The study lasts a number of days or weeks in order to get a typical picture of the body's metabolism, including its day-to-day variations.

The balance is found by subtracting the output from the intake. When the intake is larger than the output, there is a positive balance, indicating that some nitrogen has been retained in the body.

If the daily intake is 10 grams of nitrogen and output is 9 grams, the balance or retention is 1 gram.

When the intake is smaller than the output, the balance is negative, indicating a loss of nitrogen (and thus protein or protein derivatives) from the body tissues.

If the nitrogen intake is 10 grams and the output is 12 grams, the balance is a minus 2 grams. When the intake and the output are equal, the body is in nitrogen equilibrium.

Nitrogen equilibrium is the usual condition in adults when body proteins are being maintained and replenished as needed and when protein is neither being stored in the tissues nor withdrawn from them.

Positive balance is essential for growth. Only by having a large enough supply to permit storage can the body add to itself.

Negative balance is not a desirable condition. It happens when the food intake supplies too little protein to meet the body's needs.

A positive balance occurs in women during pregnancy, when new tissue is being formed, and during the nursing period, when the mother needs to store nitrogen for the protein of the milk she produces. An adult may be in positive nitrogen balance after any illness or injury that has caused a drain on the protein stores of the body.

Especially during illnesses with continued fever or severe tissue damage, or in the shock of accident, the patient is likely to be in a negative balance. Then, during recovery, protein that has been lost from the tissues is replaced before the person establishes nitrogen equilibrium again.

When an adult is increasing the amount of his muscle tissues—developing larger muscles for strength and endurance—he must be in positive balance to store the protein and other materials from which to make the added muscle. Once this is done, he will return to nitrogen equilibrium.

For children, it is important to supply the amount of protein that will permit the best retention and thus the best growth. Sometimes we refer to this as a level of protein intake above which no improvement in nitrogen retention will occur.

As an example, consider the balance study of a boy 7 years old: Perhaps on a daily intake of 20 grams of protein he just stays in nitrogen equilibrium but retains none for growth. This intake is too low for him. Then on an intake of 30 grams he stores one-half gram of nitrogen a day; on an intake of 40 grams, he stores 1 gram of nitrogen. If his protein intake is increased to 50 grams but he still retains only 1 gram of nitrogen, no more than he did when he was getting 40 grams of protein, the 40 grams then would be considered just as adequate a supply as the larger amount.

THE PROTEIN REQUIREMENT depends on how fast the body is growing and how large it is: The faster the body is growing, the more protein it needs for building. The larger the mass of living tissue, the more protein it must have for maintenance and repair.

A child grows faster during the first year than at any other time in his life. His second fastest growing period is during adolescence. His total need increases as he gets bigger, because there is more and more tissue to keep supplied and replenished with protein. Protein (or any other material) cannot be used for growth until after the needs for maintenance have been met. When there is not enough protein for both purposes, growth suffers first. The protein need is not increased by exercise or any kind of voluntary muscular activity except when the muscle is growing.

The amounts of protein needed by boys, girls, men, and women of different ages have been established through nitrogen-balance studies. The scientists who make up the Food and Nutrition Board of the National Research Council have evaluated the results obtained by the many investigators who have studied hundreds of normal men, women, and children. On that basis, the Board has set up recommended daily dietary allowances designed for the maintenance of good nutrition of healthy persons in the United States. The Board has done this for all nutrients about which there is enough information.

The recommended amounts of protein include the amount indicated by the nitrogen-balance studies plus an

Protein—Recommended Daily Dietary Allowances (1958)

FOOD AND NUTRITION BOARD—NATIONAL RESEARCH COUNCIL

Person		*Weight*		*Height*		*Protein*
	Age, years	*Pounds*	*Kilograms*	*Inches*	*Centimeters*	*Grams*
Men	25	154	70	69	175	70
	45	154	70	69	175	70
	65	154	70	69	175	70
Women	25	128	58	64	163	58
	45	128	58	64	163	58
	65	128	58	64	163	58
Pregnant (2d half)						+20
Lactating (28 ounces daily)						+40
Children	1–3	27	12	34	87	40
	4–6	40	18	43	109	50
	7–9	60	27	51	129	60
	10–12	79	36	57	144	70
Boys	13–15	108	49	64	163	85
	16–19	139	63	69	175	100
Girls	13–15	108	49	63	160	80
	16–19	120	54	64	162	75

amount (usually about 50 percent) to cover individual variations in requirements of normal people and possible differences in the protein quality of foods selected by different people. Adding an amount for a safety factor converts a minimum requirement, as determined under rigid laboratory control, to a recommended allowance suitable for broader application.

The exact amounts of protein recommended by scientists are given in terms of grams. Body weight is given in terms of kilograms. In scientific work, weights are usually expressed in micrograms, milligrams, grams, and kilograms (each one being 1,000 times the one before it) rather than in ounces and pounds and tons. The gram system is used in most countries. An ounce is really too big for measuring most of the nutrients, and using ounces to express the amount of protein needed would be a little like using gallons to express the amount of orange juice to give the baby—the fractions or decimals would be cumbersome. There are 28.4 grams in an ounce, 454.4 grams in a pound, and 2.2 pounds in a kilogram.

The protein requirement often is given as the amount needed for a specified amount of body weight. This is the simplest way to indicate the special needs for both speed of growth and body size. On a body-weight basis, the amount of protein recommended begins with as much as 3.5 grams per kilogram for the young infant (somewhat less if he is breast fed), gradually decreases to 1.5 grams in early childhood, rises again to 2 grams in late childhood and adolescence, and then settles to about 1 gram per kilogram for the average adult.

The total daily protein needs increase steadily from birth to adolescence and then decrease to a maintenance level for adulthood. The recommended allowance climbs from 40 grams of protein for children 1 to 3 years old to 70 grams for children 10 to 12 years old. At those ages, there is no difference in the recommendations made for boys and for girls.

Beginning with the age group from 12 to 15 years old, boys and girls have different patterns of growth and therefore different dietary allowances of protein. Girls mature physically earlier than boys do, and begin their rapid adolescent growth earlier. The recommended allowance therefore is highest for girls 13 to 15 years old (80 grams daily) and drops to 75 grams for girls 16 to 19 years old.

Because boys 13 to 15 years old are bigger than girls of that age, 85 grams of protein daily is the amount recommended for them. Then from 16 to 19 years, when most boys are growing most rapidly, the allowance is increased to 100 grams daily.

The recommended daily protein allowances for adults are 70 grams for the average man who weighs about 154 pounds, and 58 grams for the average woman who weighs 128 pounds. These amounts are equivalent to 1 gram of protein per kilogram of body weight, or 0.46 gram per pound, for both men and women. These figures can be used to calculate the allowances for persons who are larger or smaller than average.

A woman has another period of rapid growth, and thus an increased protein need, when she is an expectant mother. During the second half of pregnancy, when the fetus is growing rapidly, the recommended daily allowance is for an additional 20 grams of protein, which raises her total intake to 78 grams daily. At this time she needs a chance to store protein not only for the growth of the baby but for her own tissues in preparation for milk production. Much of the success in nursing a baby depends on the mother's nutrition before the baby comes.

The mother's total protein allowance when she is nursing her baby is the highest of any time in her life. Forty grams, in addition to her prepregnancy needs, are recommended, so that her total daily recommended intake is now 98 grams. Sometimes it is hard for a mother to realize that she needs more of every kind of nutrient during lactation than she did during pregnancy.

ADULTS CAN BE in nitrogen equilibrium on intakes considerably lower than the recommended allowances.

The body adjusts itself to a low intake by reducing its body stores of the protein in order to cut down the amount it needs for maintenance or overhead. This does not mean that low intakes are advisable. In fact, the reverse is true. Studies of the nutrition of individuals and groups of adults and children show that a generous supply of protein in the diet contributes noticeably to nutritional status and well-being at every age.

All these recommendations for people in the United States assume that some of the protein will come from animal sources. They also assume that the diet will be adequate in calories and other essential nutrients, so that the protein can be used with greatest efficiency and benefit to the body.

SUPPLYING ENOUGH protein is not a major nutritional problem in this country. The average diet is more likely to be adequate, or is more nearly adequate, in protein than in almost any other nutritional essential except calories. There is an average of 97 grams of protein per capita in available household food supplies; two-thirds of this protein is from animal sources. This reflects a high level of economic prosperity as well as certain food preferences.

Despite the high average figures for the amount of protein consumed by the people, certain groups of individuals in some situations have an inadequate supply—for example, during periods of adolescence, pregnancy, and lactation; in reducing diets; when people prefer foods high in starch, sugar, or fat; and among poor people.

Supplies of protein foods are a major problem for many countries—especially the underdeveloped, populous countries. Protein malnutrition in children and adults may result in stunted growth, lack of muscle development, and lowered resistance to disease. It is most prevalent in children 1 to 5 years old. Many children have the protein-deficiency disease, kwashiorkor (quash-i-or′-kor). This disease occurs soon after a child is weaned and yet is too young to thrive on the food that the adults have. The adult diet in many countries is far from adequate for normal growth and sometimes is barely sufficient to keep the adult body alive.

Because of its prevalence, high death rate, and its preventable nature, kwashiorkor was of serious concern to health and nutrition workers in many parts of the world in 1959. Progress has been made in learning how to supply the needed protein and in helping families learn about improved feeding and care of children.

In underdeveloped and heavily populated countries, cereal grains have to be the chief item of diet because they are the quickest, easiest, and cheapest food to produce in quantity. The proteins from cereals alone are not of high enough nutritional value for normal growth and efficient maintenance. Although some proteins from animals or certain legumes are essential, enough of them may not always be available.

We have come to realize that perhaps some of the chemical units that make meat, milk, and eggs superior foods for filling the protein needs of people may be supplied by skillfully combining certain foods from plant sources in special proportions. For that, our knowledge of the chemistry and requirements of amino acids is most useful.

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The diet revolution is likely to take two directions "fairly rapidly," predicts Dr. C. G. King, executive director of the Nutrition Foundation. About half of the world's population will increase its food intake, the other half eat less.

In this country, particularly, less consumption in quantity is expected. The constant reminder of health authorities that 25 per cent of the population is overweight, and that obesity is associated with seven of the 10 leading causes of death and crippling diseases, is expected to influence diet habits. The trend toward less physical work as a result of mechanization should also lighten food consumption.

Yet the temptation to overeat will also increase, Dr. King warns, because of relatively high incomes and an abundance of attractive foods.

In fact, the lower income groups could wind up the better fed. In areas where population and economics limit food supplies, research advances, Dr. King predicts, may permit blending of low-cost plant proteins to furnish desired intakes of amino acids. This supplementation of animal protein foods, he says, "will be of critical importance for infants, growing children and mothers."—MALVINA LINDSAY. Washington Post, November 27, 1958.