

# Max Rubner

1854-1932

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Few people have made contributions to the field of metabolism comparable to those of Max Rubner. His development of the Isodynamic Law and the Law of Surface Area, and the determination of the caloric equivalents of foodstuffs along with other fundamental work, gave impetus to studies of energy metabolism.

Max Rubner was born in Munich on June 2, 1854.

He received his early training under Carl Voit in Munich. During this time he was associated also with Pettenkofer. Voit and Pettenkofer had recently developed a method of estimating carbon dioxide, and this procedure enabled Rubner to carry out his studies. He also spent a year with Carl Ludwig at Leipzig.

When Rubner was twenty-four he embarked on experi-

ments to determine the rates of catabolism of carbohydrates, fats and proteins in fasting animals. One of his early contributions was the demonstration that 25 per cent of the total heat value of protein is lost to the body by the incomplete oxidation of nitrogen products. Following other studies Rubner came to the conclusion that the three major foodstuffs, carbohydrates, protein and fat could replace each other in accordance with their heat-producing value. This concept was termed the Isodynamic Law. At the time, he determined that 1 gm. of dry protein would produce 4.1 calories, 1 gm. of carbohydrate 4.1 calories, and 1 gm. of fat 9.3 calories during metabolism. These values are used, of course, universally. Voit was not in complete agreement with the Isodynamic Law, and full publication did not occur until 1883.

While still in Munich, Rubner also developed his Law of Surface Area. Following experiments on different species he concluded that in mammals, heat production was proportioned to the surface area. Using Meck's formula for calculating surface area he was able to show that the metabolism of a man per surface area was the same whether he was fasting or consuming a moderate diet. A similar relation was also found in animals and domestic farm birds.

In 1885 Rubner became Professor of Hygiene at Marburg. By 1889, he had with great effort and limited funds assembled and perfected a calorimeter. He carried out an experiment wherein a dog lived in the calorimeter for forty-five days. During this time 17,406 calories were calculated from expired carbon dioxide and excreted nitrogen. The calories measured by the calorimeter were 17,349, a remarkable agreement with those calculated. This elegant experiment established the law of conservation of energy in metabolism. No energy was available, except that resulting from chemical reactions.

Rubner was appointed Professor of Hygiene at Berlin in 1891. Eighteen years later he became Professor of Physiology, a position he held until his retirement in 1924. His work continued in Berlin. The surface area law was found to hold in a variety of species. Of particular interest to him was the "specific dynamic action" of foodstuffs, especially protein. He believed that specific dynamic action was due to the heat production of intermediary metabolism. Studies were conducted on the energy requirements during growth. Karl Thomas, working in his laboratory, showed that a man would excrete 2.2 gm. of nitrogen in the urine while on a starch and cream diet. Rubner termed this the

"wear and tear" breakdown of protein, the minimum that would be excreted in the course of a protein-free input. In World War I, experiments were conducted on the nutritive values of different breads. It was found that white and rye bread were as nutritious as any other type.

Atwater and Lusk worked in Voit's laboratory while Rubner was there. Both were greatly influenced by Rubner and brought his ideas and methods to America. Benedict, in turn, worked with Atwater and then conducted his now classical studies of the fasting man in the Carnegie Institute in Washington. Lusk became Professor of Physiology at Cornell, where DuBois applied the methods to clinical research in the Russell Sage Institute at Bellevue Hospital. Benedict developed the current method of determining basal metabolic rates, and DuBois extensively studied caloric expenditure in a variety of disease states.

Thus the concepts of Rubner were seeded and grew in this country.

Lusk knew Rubner intimately and wrote of his friendship with him. He stated that, when Rubner was a young man, he liked to wear gay clothes and climb the Tyrolean mountains. However, in later life the dignity of the professional position demanded austere behavior and formality. Rubner was tall and of striking presence. He was often ruthless in debates with his colleagues. He liked to paint, and enjoyed relaxation among artist friends. Lusk quoted Karl Thomas as saying that Rubner was slow to give his confidence to anyone, but once he had given it he never withdrew it.

Rubner came to this country in 1912 to attend the International Congress of Hygiene and Demography in Washington. He visited Lusk in Long Island and journeyed to the Pacific Coast. He told Lusk that the Pacific Coast was finer than Nice, where he spent his Easter holidays.

In a later letter to Lusk, he stated that, though America was considered a "land of the dollar" in Europe, he found that young American scientists were dedicated despite their penurious salaries.

In the latter part of his retirement, Rubner became quite concerned about the welfare of the teaching profession. He wrote to Lusk in 1930 that something should be done about improving the retirement pay of teachers, as well as their salaries.

Rubner died in Berlin on April 27, 1932, a month before his seventy-eighth birthday. Shortly thereafter, Lusk delivered an address to a general session of the

American Association of the Advancement of Science. In this address he succinctly described Rubner as having ". . . the power of arriving at great results through simple means, and of drawing correct conclusions from a few well-conducted experiments." Lusk considered Rubner the greatest man he had ever known.

## REFERENCES

- Chambers, William H.: Max Rubner. *J. Nutrition* 48:3-12, Sept.-Dec. 1952.  
Lusk, Graham: Contributions to the science of nutrition, a tribute to the life and work of Max Rubner. *Science* 76:129-35, Aug. 12, 1932.

## CORRESPONDENCE

To the Editor:

In an article which appeared in the November-December 1956 issue of *DIABETES*, H. S. Seltzer et al. state that glucose tolerance curves in which initial hyperglycemia is followed by a fall of blood sugar to hypoglycemic levels are diagnostic of mild diabetes mellitus, and that the hypoglycemia recorded in such curves constitutes an early manifestation of the diabetic state. Such interpretation of initially high glucose tolerance curves seems to me unjustified and fraught with the danger of making the diagnosis of diabetes mellitus in a number of nondiabetic subjects who may exhibit this type of blood sugar response to oral glucose loading.

The significance of glucose tolerance curves with an early excessive elevation of blood glucose and a secondary hypoglycemia has been a matter of concern for a number of years and, for the sake of proper historical perspective, it should be pointed out that such curves were first reported by Seale Harris in 1924.<sup>1</sup> Although he was aware that the curves may appear diabetic during the first three or four hours of the test he considered patients with this type of tolerance curve as potential, but not real, diabetics.<sup>1, 2</sup> A similar view was recently voiced by Skillern and Rynearson<sup>3</sup> who regard such curves as indicative of latent diabetes, while a position similar to that of Seltzer et al. was taken about a decade ago by Zondek et al.<sup>4</sup> who expressed the belief that such curves represent "joint occurrence of hyper- and hypoinsulinism."

In referring to my observations on glucose tolerance curves with initial hyperglycemia and secondary hypoglycemia<sup>5, 6</sup> Seltzer et al. make an entirely unfounded statement in saying that I have overlooked the existence of diabetes in such cases and have applied to them an erroneous diagnosis of functional hyperinsulinism. The fact, however, is that the diagnosis of diabetes in these cases was not overlooked, but simply ruled out for a number of reasons that were considered in great detail.

Thus in my paper on "Clinical versus Laboratory Hypoglycemia"<sup>5</sup> in which thirty-three such curves were analyzed, I have brought out that: a. in seven curves the two-hour blood glucose readings were only slightly higher than normal; b. in nine the blood glucose values fell at first to 100 mg. per cent or less, and then rose to reach higher levels (so-called rebound curves); c. in none of the thirty-three tests did the peak glucose concentration in the capillary blood exceed the normal values; and d. in all thirty-three a fall to subnormal levels occurred in the second phase of the test. I have therefore concluded that "These findings do not support the diagnosis of diabetes, a condition in which the disorder of carbohydrate metabolism is reflected in a high, prolonged tolerance curve."

It is well known that hyperglycemia confined to the first two or three hours after administration of the loading dose may occur in various conditions unrelated to diabetes, such as the dumping syndrome, peptic ulcer, liver disease, hyperthyroidism, et cetera. For this reason, in absence of clinical manifestations of diabetes, an initially high glucose tolerance curve is not necessarily diagnostic of diabetes. A scrupulous search for the various conditions which may give rise to initial hyperglycemia in glucose loading tests was made in my material, but from the data presented by Seltzer et al., it appears that in their series only routine liver function tests were carried out with regard to the differential diagnosis of diabetes.

Another important point in the interpretation of initially high and secondarily low glucose tolerance curves is the fact that the curve pattern may vary in the same subject from one test to another. Seale Harris<sup>2</sup> stated: "one glucose tolerance test is not always sufficient to warrant a positive diagnosis of hyperinsulinism since there seem to be periods when the hyperinsulinism patient will have normal blood sugar readings, even though at other times he has shown marked hypoglycemia." My observations, on the other hand, show that the initial hyperglycemia of glucose tolerance tests

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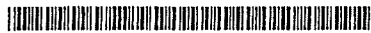
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