MRI
Max Rubner-Institut

Max Rubner

Pioneer of Nutrition Science

„We never had a special institute or even an institution that could have addressed issues of human nutrition and the nation's nutrition."

Max Rubner, 1921

Max Rubner: Pioneer of Nutrition Science

Max Rubner was born in 1854 during a period of great social upheaval which was to have a profound influence on his life and work. Industrialisation had an impact on all areas of life, including medicine, which increasingly addressed the topic of nutrition.

Traditionally, nutrition played a major role in medicine because until the middle of the 19th century, nutrition was effectively used as treatment. For some diseases doctors prescribed specific foodstuffs as a therapeutic and preventive measure.[1] Now that chemistry, biology and physics were establishing themselves as subjects, nutrition researchers were able to apply scientific methods.[2] Max Rubner experienced the "health and hygiene revolution"[3] that ensued first hand, indeed he saw himself as part of it. "With the rise of the natural sciences in this century the time has also come for health science to break through the narrow boundaries of empirical observation and replace wide-ranging suppositions with the certainty of experimental methods."[4] This marked the birth of nutrition science which for Rubner meant "the great, comprehensive goal of studying the nutritional processes in all living creatures."[5]

He chose two parallel paths on his quest to achieve this scientific goal: research into digestion and bodily energy. But Max Rubner did not only conduct research for research's sake. Like many contemporary doctors, Rubner considered scientists to be under an obligation to advise the country in the period between the Franco-Prussian War and the First World when the protection of the labour force and battle readiness of the population were high priorities.[6]

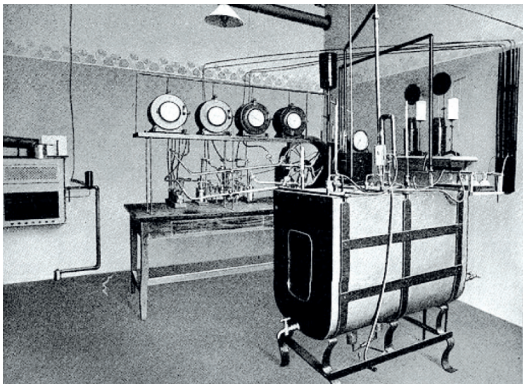
Ultilisation of foodstuffs in the human gut

Max Rubner experienced the Franco-Prussian War of 1870/71 as a 16-year-old working in a military hospital. It was here that he developed an interest in medicine. Shortly after the end of the war, he did then start studying medicine in Munich where he subsequently completed a doctorate, "On the utilisation of certain foodstuffs in the human alimentary canal"[7] – a topic to which he would return again and again.

We can gain an insight into Rubner's enthusiasm for experimentation on the theme of digestibility from a "human experiment" he conducted on an individual, probably his servant, in 1880. For days, the latter exclusively ate peas: "The proband ate the daily ration at three meals. [...] Freshly tested, the faeces were always acidic and, both in appearance and consistency, resembled the food that had been eaten. It was remarkable that they did not appear to be full of gas bubbles although the proband complained bitterly about suffering gas in the gut. [...] The reason for this unfavourable reaction is, however, obvious: too much of the foodstuff was eaten leading to an overloading of the gut."[8] This experiment not only recalls Büchner's Woyzeck, which appeared the year previously and features a scientific experiment involving peas, it also shaped Rubner's belief that nutrition should always be varied: "A monotonous diet is a dangerous cliff-edge in nutrition and meals. We don't only long for dishes that contain stimulants, but also considerable variation therein. People who are expected to eat the same things every day develop revulsion and aversion which may continue for months and years. This desire for variety is one of the most important guardians protecting the normal composition of our bodies."[9] Easier said than done: ordinary people's diet was hardly varied at all. They ate porridge for breakfast and lunch. And in the evening? Porridge! Meat, fresh fruit and vegetables were expensive and the preserve of the wealthy members of society.

In 1883, Rubner's digestion research led him to examine the "value of wheat bran for human nutrition". The topic of whole grains had transferred from natural medicine to traditional medicine. Rubner himself investigated whether the whole grain with its outer layers was really as healthy as claimed. He came to the conclusion that most of the bran was "cellulose that is impossible for humans to digest."[10] In order to underpin his assertion, Rubner cited an experiment by Poggiale, an Italian doctor who fed a dog bran and then "reconstructed the bran from the dog's faeces." He then fed it to another dog and once again extracted the bran from its faeces, finally feeding it to a chicken. Sixty-six percent of the constituents had "withstood being digested" by the three animals.[11] Rubner therefore described these constituents as "Ballast für den Magen" (burden for the stomach).[12] The description, "Ballast", gave rise to the current German term for dietary fibre, "Ballaststoffe." Today, however, we know that dietary fibre is by no means a superfluous food but has many positive properties, including improving the functioning of the gut.

Counting calories Rubner-style



Max Rubner's calorimeter, 1911

Both whilst he was still at university and subsequently, Rubner was employed by Carl von Voit at the Physiological Institute in Munich. Voit was a pupil of Justus von Liebig and, together with the chemist Max von Pettenkofer, constructed a calorimeter for animals. The results of their experiments suggested that the only source of energy available to humans was what they took from nature and ingested via the food they ate. Max Rubner proved this theory by burning dried excrement and investigating how much heat was released when its nitrogen content burnt. The name for a physical unit of heat, calorie, comes from the Latin ("calor" = heat). As a result of these combustion experiments the term was applied to the amount of energy contained in food, which is consequently known as the calorific value. In this context, Rubner calculated that one gram of protein was equivalent to 4.1 calories, one gram of fat to 9.3 calories and one gram of carbohydrates to 4.1 calories.[13] We are familiar with these figures from today's calorie chart. Rubner thus proved that, apart from carbohydrates and fat, protein also provides the body with energy. He did not go quite as far as Liebig, who referred to protein as the "source of energy"[14], but he emphasised that "four to six percent of the entire energy metabolism" had to be "covered by protein."[15] If this protein minimum was not achieved, the body would lose nitrogen and the concomitant wastage would lead to cell death.

During his time in Marburg, where he held the Chair in Hygiene and State Pharmacology from 1885 to 1891, Rubner himself constructed a calorimeter. It took account of heat loss by condensation[16], an innovation with which he achieved his breakthrough. He tested the functionality of his calorimeter on his dog, which lived in the calorimeter for 45 days, "burning" 17,439 calories. The fact that this almost exactly equated to the nitrogen in the animals' excrement, indicating that the calorimeter was very precise, gained Rubner the admiration of his contemporaries.[17] Whilst experimenting with his own calorimeter, Rubner also noticed that an animal with a larger surface area produced more heat, that is, used more energy. He consequently formulated the Law of Surface Area[18] that is also still in use today.

Science at the service of the people

Exercise Room for chemistry at the Friedrichs-Wilhelms-University

From 1891, Max Rubner worked in Berlin, succeeding Robert Koch to the Chair of Hygiene at Friedrich-Wilhelms-University (today's Humboldt University). Here he experienced the social impact of high industrialisation. The cities were bursting at the seams, poor housing and an unbalanced diet were responsible for disease and malnutrition.
At the time, the primary goal of food was to provide energy. Counting calories was a way of fighting undernutrition, not obesity, as it is today.[19] The "comparison of work capacity with food intake"[20] was another of Rubner's research goals; on the cusp of the World War I, it was necessary to measure the population's food requirements in order to be able to cover them in wartime. In 1914, Rubner therefore wrote to the German government that the nation's food supplies needed to be secured in the forthcoming war and that a number of measures would have to be introduced to do so. He received a short reply from the Deputy Minister of War: the war would soon be over so there was no danger of food shortages.[21] Just how wrong he and many others had been, became apparent very soon. By the end of the war, 750,000 Germans had died of malnutrition.[22] Against an average daily requirement of 2,280 calories, the state-regulated food rations sometimes only delivered 1,000.[23]

In consequence, Germans ate ever more ersatz food – almost 11,000 different products were available on the market.[24] They were not without health risks, which Rubner analyzed. He studied, for example, how digestible it was to eke out bread with wood flour. Once again, a dog was used as a meat-eating guinea pig: wood flour was added to its meat feed and, surprise, surprise, although its excrement contained more ash and had a "tendency to form hard lumps of matted substances," it was nonetheless "free of malodours."[25] He still could not guarantee, however, that it was risk-free to eat bread laced with wood flour.

Max Rubner now placed his science entirely at the service of the state. In his role as the leading medical advisor to the first German democratic government under Friedrich Ebert,[26] in 1921, he noted the absence of "a special institute or even an institution that could have addressed issues of human nutrition and the nation's nutrition."[27] After his death in 1932, it took another 76 years before a Federal Research Institute for Nutrition and Food was established. Founded in 2008, it is just as interdisciplinary in its approach as Max Rubner was himself – and is named after him.

Sources

1 Worth Estes, J., Food as Medicine, in The Cambridge World History of Food, eds. Kenneth F. Kiple and Kriemhild Coneè Ornelas, Cambridge 2000, p. 1534.

2 Cf. Leitzmann, Claus, Stange, Rainer, Die Geschichte naturheilkundlicher Ernährungskonzepte, p. 8.

3, Briesen, Detlef, Das gesunde Leben. Ernährung und Gesundheit seit dem 18. Jahrhundert, Frankfurt/Main 2010, p. 119.

4,9,13 Rubner, Max, Lehrbuch der Hygiene: Systematische Darstellung der Hygiene und ihrer wichtigsten Untersuchungs-Methoden, revised third edition, Leipzig 1890, pp. 1, 460, 432.

5,27 Rubner, Max: Die Lage der Ernährungswissenschaft in Deutschland, 1921, pp. 340-341.

6,22,23,24,26 Eckart, Wolfgang, Illustrierte Geschichte der Medizin. Von der französischen Revolution bis zur Gegenwart, Berlin – Heidelberg 2010, pp. 116, 259.

7 Peer, Elisabeth Maria, Max Rubner. Forscher und Mensch. 1854 – 1932, Wattens 1983, p. 8.

8 Rubner, Max, 'Ueber die Ausnutzung der Erbsen im Darmkanale des Menschen' in Zeitschrift für Biologie, Vol 16 (1880), p. 120 ff.

10,11,12 Rubner, Max, 'Ueber den Werth der Weizenkleie für die Ernährung des Menschen' in Zeitschrift für Biologie 19, München – Leipzig 1883, p. 49.

14,15 Rubner, Max, 'Verluste und Wiedererneuerung im Lebensprozeß' in Archiv für Anatomie und Physiologie (1911), pp. 50, 49.

16 Opitz, Bernhard, Der interzelluläre Kreislauf: biothermodynamische Voraussetzungen und mögliche metabolische Steuerungen, Books on demand 2009, p. 45 ff.

17,18 Lusk, Graham, 'Contributions to the Science of Nutrition. A Tribute to the Life and Work of Max Rubner' in Science (Vol 76, 1932), pp. 130, 132.

19 Brabeck-Letmathe, Peter, Ernährung für ein besseres Leben. Eine Reise von den Anfängen der industriellen Nahrungsproduktion zur Nutrigenomik, Frankfurt/Main 2016, p. 37.

20 Rubner, Max, Die Beziehung zwischen Nahrungsaufwand und körperlichen Leistungen des Menschen, 1926, p. 391.

21 Rössner, Stephan 'Max Rubner (1854-1932)' in: Obesity Reviews (2013), p. 432.

25 Rubner, Max 'Die Verdaulichkeit des Birkenholzes bei wechselnden Mengen der Zufuhr' in Archiv für Anatomie und Physiologie/Physiologische Abteilung (1915), p. 107

Picture credits

p.3 Rubner, Max, Calorimetry, in Handbuch der physiologischen Methodik, Vol. 1, Part 3, ed. Robert Tigerstedt, Leipzig 1911, p. 207.

p.4 Rubner, Max, The Hygiene Institute of Berlin University, in Medizinische Anstalten auf dem Gebiete der Volksgesundheitspflege in Preußen. Festschrift, ed. Preußischer Minister der geistlichen, Unterrichts- und Medizinal-Angelegenheiten, Jena 1907, p. I-22.

Text

Beate Matthes, Max Rubner-Institut, 2018

Max Rubner-Institut
Federal Research Institute of Nutrition and Food

Address Haid-und-Neu-Straße 9, 76131 Karlsruhe · Germany
Phone +49 (0)721 6625-201
Fax +49 (0)721 6625-111
Email kontakt@mri.bund.de
Web www.mri.bund.de
Twitter @MRI_Aktuelles