Measuring Man's Needs*

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Man's most fundamental need is for food. The questions "What foods should be eaten?" and "How much of them are required?" have been asked since man recognized a relationship between his food and his health. Empirical ration scales have been in use from ancient times; our word salary is, of course, derived from the term for money allowed to Roman soldiers to buy their salt ration. Early records of monasteries, hospitals, institutions for the poor, houses of correction, and the army and navy provide a variety of examples of ration allowances. These kinds of scales were based, very generally, on such things as tradition, religious and practical factors, money available, and the apparent health of those taking the ration. They continued in use with some variations for centuries. It was not until the mid-nineteenth century that a workable quantitative basis for calculating the food requirements of man was established.

The first generally accepted figures were those of the Dutch physician Jacob Moleschott (1822–1893) published originally in *Wiener Medizinische Wochenschrifte*, May 14, 1859.[1] and then included in the second edition of his *Physiologie der Nahrungsmittel: ein Handbuch der Diätetik*.[2] Moleschott's "numbers" or "figures," as they were called, referred to the amounts of chemical elements required from food in terms of alimentary principles.[3] His calculations indicated the needs, per day, of an

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[1] "Von der Menge, in welcher die einzelnen Nahrungsstoffe zu einer vollständigen Erhährung erfordert werden" was section VIII.

[2] Published in Giessen by Ferber in 1859. The first edition was published in Darmstadt in 1850 and was based on the work of Moleschott's former teacher, F. Tiedmann (1787–1861).

[3] Alimentary principles were understood to be "all those compounds which are either identical with the essential constituents of blood, or

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active man of average body weight, and provided a standard still referred to by writers in the twentieth century.[4]

The object of this paper is to consider some of the developments in thought that enabled Moleschott to formulate his quantified dietary standard.

The delay in providing such a standard was certainly not due to lack of interest. This is clearly shown by the emphatic way in which writers, through the centuries, have explained that a standard diet was impossible to formulate. Thomas Newton translating Gratarolus in 1574 said: "Even as a shoomaker cannot make one shooe to serve every mannes foote, so neither can a Phisicion describe and appoint any one generall order and dietarie for all manner of persons." [5] Under the humoral doctrine, accepted in the sixteenth century, it was particularly difficult to make any standard for food intake because the predominant qualities in foods (i.e., hot or cold, dry or moist) acted upon the dominant qualities of the body, and their effect therefore depended upon the complexion of the eater.[6] Besides this, food and drink were only one of six non-naturals (air; meat and drink; sleep and watch; movement and rest; emptiness and repletion; and affections of the mind),[7] all of which had to be considered when formulating the whole diet or regimen. At that time and in subsequent centuries the appetite was relied upon as a proper guide to the quantity of food required.

In the nineteenth century, with the recognition that the body and foodstuffs were composed of the same basic chemical elements and the rejection of the traditional idea of "one aliment," [8] it was possible to be more specific about the human body's needs for various foods. However, J. A. Paris, himself an advocate of the application of chemical ideas to medicine, says in his *Treatise*

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sufficiently similar to be transformed into them by digestion." This definition is given on p. 331 of "The Chemistry of Food" (i.e., E. Bronner's translation of Moleschott's *Lehre der Nahrungsmittel de Volk)* in Orr's Circle of the Sciences: *Practical Chemistry,* G. Gore, M. Sparling, and J. Scoffern eds. (London: Houlston & Stoneman, 1856).

[4] R. Hutchison and V. H. Mottram, *Food and the Principles of Dietetics,* 7th ed. (London: Arnold, 1933), p. 42. (1st ed., 1900) Here, only the figure for protein (albuminous material) agrees exactly with Moleschott's original.

[5] Gulielmus Gratarolus, *A Direction for the Health of Magistrates and Students,* trans. T. Newton (London: William How, 1547), Sig. B3^r.

[6] Individuals could be grouped under four types of complexions or temperaments; *Sanguine* (hot: moist); *Choleric* (hot: dry); *Phlegmatic* (cold: moist) and *Melancholy* (cold: dry).

[7] This list of six non-naturals is taken from T. Elyot, *The Castel of Helth* (London: T. Berthele, 1541), Sig. B1^r.

[8] The tradition of "one aliment" is said to be derived from Hippocrates. It was questioned by F. Magendie (1783–1855) in *Précis elémentaire de physiologie* (Paris: Méquignon-Marvis, 1816), II, 3, n. 1, and rejected by

on Diet (1837) that it is absurd to try to establish a rule of weight and measure for the quantity of food which ought to be taken, as the capacities of individuals vary so greatly.[9]

Despite the attitude of physicians, from the sixteenth century onward a kind of standard had been chosen. This was the strict regimen of a Venetian gentleman named Luigi Cornaro, who stated that he had lived to a vigorous old age by taking only 12 ounces of food and 14 ounces of wine each day. His story is particularly dramatic because at about forty years of age he was near to death due to an excessive way of life, but he was reprieved by turning to his strict diet and lived to be more than one hundred years old.[10] Since his death in 1566 Cornaro's diet has been referred to constantly by such diverse authors as Mr. Addison in *The Spectator* of 1711 and Miller and Payne in the 1969 *Proceedings of the Nutrition Society*.[11] The references through the centuries are so numerous that one feels inclined to reiterate with Father Feyjoo of Montenegro (in his Treatro Critico of 1733) that surely "God did not create Lewis Cornaro to be a rule for all mankind in what they eat or drink." [12]

In the 1855 edition of *Principles of Human Physiology*, W. B. Carpenter refers to Cornaro's diet but in terms of a subsistence level. He repeats that appetite is the only guide and that no universal law can be laid down regarding the quantities of food to be taken. He adds that it is important, from the practical point of view, to form a correct average estimate of what is needed.[13]

Today we all agree, with Gratarolus, that it is impossible to make a shoe to fit every foot. The modern approach is to try to make what might be called an overshoe intended to be suitable for the feet of all the people within a particular group. This is the approach used in the recent *Recommended Intakes of Nutrients for the United Kingdom* (1969), which provides figures for ten nutrients with additional advice on more than

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William Prout (1785–1850) in "On the ultimate composition of simple alimentary substances," *Phil. Trans. Roy. Soc.*, London (1827), pt. 2, 355–388.

[9] J. A. Paris, *A Treatise on Diet*, 5th ed. (London: Sherwood, Gilbert & Piper, 1837), p. 148. (1st ed., 1826). Paris also wrote *The Elements of Medical Chemistry* (London: Phillips, 1825).

[10] See Lewis Cornaro (trans. from the Italian), *Sure Methods of attaining a Long and Healthful Life: with the means of correcting a bad constitution*, 34th ed. (London: J. Anderson, 1822).

[11] Joseph Addison, *The Spectator*, no. 195, Oct. 13, 1711; D. S. Miller and P. R. Payne, "Assessment of protein Requirements," *proc. Nutr. Soc.*, 28 (1969), 226.

[12] B. G. Feyjoo y Montenegro (trans. from the Spanish), *Rules for Preserving Health* (London: R. Fauldner, 1800), p. 82.

[13] W. B. Carpenter (1813–1885), *Principles of Human Physiology*, 5th ed. (London: J. Churchill, 1855), pp. 45 and 47. (1st ed., 1843).

fourteen others not tabulated. The information given is applicable to people in twenty-one different groups of the population.[14] The tables are based on accepted chemical and physical laws which are quantifiable and general in their application, and derived, on the whole, from the early nineteenth century. Nutrients, used as units, are identifiable by their chemical composition; this can be equally well applied to the needs of the human body or, with the help of food composition tables, to the contents of foodstuffs.

A study of modern tables and Moleschott's comparatively rudimentary recommendations shows that his work is clearly a forerunner of today's methods.

At the beginning of his chapter entitled "On the Quantity of Different Individual Foods Required for Complete Nourishment" Moleschott said:

> The statement that one cannot determine the quantity, by weight, of foods needed by man is based on the fact that people have continuously forgotten to ask themselves for what unit of body weight and time the weight [of the food] ratios should be given."[15]

Moleschott then explained that by using precisely defined units and by considering the various demands made upon man, a carefully calculated minimum requirement of food can be established.[16] The figures he gave are shown in Table 1.

Table I For a Working Man Weighing 63.65 kg[17]

Per day

		Active		*Resting*
Nitrogenous	Albuminous material	130g.		60g.
Nitrogen-free	fat	84g.	488g.	430g.
	fat-former	404g.		
Salt		30g.		
Water		2,800g.		
	TOTAL	3,448g.		

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[14] Great Britain, Department of Health and Social Security, *Recommended Intakes of Nutrients for the United Kingdom*, Reports on Public Health and Medical Subjects no. 120 (London: H.M.S.O., 1969). The latest U.S. National Research Council figures for Recommended Dietary Allowances tabulate seventeen nutrients and refer to twenty-six groups.

[15] Moleschott, *Physiologie* (1859), pp. 216–217.

[16] Ibid., p. 217.

[17] Ibid., pp. 223, 225.

Comments on Table 1

Moleschott followed Liebig's theories, first put forward in *Animal Chemistry* (1842),[18] and gave his quantities in terms of nitrogenous (plastic) materials capable of supporting growth and movement and nitrogen-free (respiratory) materials which provided heat for the body. Because movement was considered to result from the breakdown of nitrogenous tissues a resting man required fewer albuminous foods. The quantity of heat-giving foods remained approximately the same. Moleschott used the term *Fettbildner* for carbohydrates, although Carl Schmidt had introduced the word carbohydrate in 1844.[19] In the controversy over the formation of body fat from amylaceous materials, Moleschott believed that fat could be formed in the body from carbohydrates.[20]

The following ratios were given, N:N-free 1:3.7; fat to fat-formers 1:4.84.

The standard provided Nitrogen 308.6 grains or 20g.
Carbon 4,629 grains or 300g.

The weights of alimentary principles were given as "water-free," their water content being included in the total water. Earlier in the century Berzelius had improved his analytical techniques by drying his material, and later William Prout had stressed the necessity of drying foods to be analyzed.[21] Tables of food analysis show that some foods were dried to 212°F or *in vacuo* 230°F.[22] For some years after the publication of Moleschott's figures standards were sometimes given in terms of 'water-free' foods. Care has to be taken not to confuse this meaning of 'dry' with the term 'dry foods' which was used to differentiate between dry foods and drinks.

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[18] J. Liebig, *Animal Chemistry, or Organic Chemistry in its applications to Physiology and Pathology* . . . Edited from the author's manuscript by W. Gregory (London: Taylor & Walton, 1842).

[19] C. Schmidt (1822–1894) [Liebig's] *Annalen der Chemie, 51* (1844), 30. In "The Chemistry of Food" (see n. 3 above) p. 308, Moleschott described starch, gum, and sugar as important *constituents of fat.*

[20] In this he followed the German school of thought under Liebig. During the controversy many French workers (e.g., J. B. A. Dumas and J. B. Boussingault) held the view that all fat in the body was derived from the fat in foods.

[21] W. H. Brock, "The Life and Work of William Prout," *Medical History, 9* (1965), 101–126.

[22] See J. Pereira, *A Treatise on Food and Diet* (London: Longman, Brown, Green & Longmans, 1843), p. 80.

The energy value of Moleschott's standard was estimated by later workers as 3,160 kcal,[23] although this figure can vary according to the method of calculation used.

Moleschott obtained his results by using two methods checked against each other.

1) By studying the food intakes of healthy active men. He used twenty-one reported dietaries, collected by seven workers from various countries.

2) By observation and by calculation, he related the amount of nitrogen, carbon, hydrogen, and oxygen excreted, in twenty-four hours, by his "reference man," back to food intake. He recognized that this method could give only a rough representation of the food eaten, but he believed it to be a useful check.

Basically, this is a similar method to that used today, which still fundamentally depends on the results of dietary surveys and metabolic balance studies. However, Moleschott in his detailed calculations used too many related assumptions for his calculations to be compared directly with modern methods.[24] It is on the background to the following three points, raised by Moleschott's work, that comment is given in this paper:

A) The use of the unit of body weight;

B) The studies of food intakes available to him;

C) The attempts to balance food intakes and excretions.

A) THE UNIT OF BODY WEIGHT

The figure 63.65 kg used by Moleschott as his reference unit of body weight comes from the works of Adolphe Quetelet (1796–1874), the Belgian astronomer, mathematician, and statistician. The use of this figure is of interest both from the point of view of body-weight records and from the whole concept of the average man.

Today most of us are likely to have been weighed and measured at some time in adult life, but the taking of this type of record is of recent origin. In the past, the comparative weight of healthy adults was not thought to have any particular significance, though sick persons, cared for in monasteries, had

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[23] Hutchison and Mottram, *Food and Dietetics,* p. 42.

[24] Moleschott used ratios (e.g., N:N–free) from his dietary intake figures in his calculation of food intake from excretions. The results of this calculation were then used as a check against the suitability of the dietary records he had used.

been weighed as part of their treatment in some cases. Abbé Jaubert, writing in 1764, said that the chapel of *La Balance* derived its name from this custom.[25] The use of measurement to determine the rates of human growth is said to have originated with Buffon,[26] and workers in the next century developed this method. In France, F. Chaussier measured the growth of infants and in England W. R. Cowell reported to the Factory Commission of 1833 on the comparative heights and weights of children working in factories and of those outside.[27] Before the nineteenth century, apart from individual cases, few records are available of the heights and weights of healthy adults. In 1793 the famous French physician J.-R. Tenon weighed and measured sixty men in a village outside Paris, while concern about the poor physique of army recruits led first to the work of A. A. Hargenvilliers[28] and later to the surveys of L.-R. Villermé in 1829.[29] About this time a number of students were weighed and measured at Cambridge University, for Quetelet reports that William Whewell sent him some eighty records.[30]

The first comprehensive records of adult body-weight can be found in "Recherches sur le poids de l'homme aux différens âges," published by Quetelet in *Nouveaux mémoires de l'Académie Royale des Science et Belle lettres de Bruxelles* (1833).[31] This material was repeated in subsequent publications, including Quetelet's important work *Sur l'homme et le développement de ses facultés* of 1855.[32]

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[25] P. Jaubert, *Dictionnaire raisonné universel des arts et métiers* (Paris: Didot jeune, 1773), III, 445. (1st ed., 1764).

[26] Le Comte de Buffon (1707–1788), *L'Histoire naturelle* (Paris: Imprimerie Royale, 1749), *L'Histoire naturelle de l'homme*, p. 472.

[27] F. Chaussier (1746–1828), *Mémoire medico-légal sur la viabilité de l'enfant naissant* (Paris: Compère jeune, 1826). W. R. Cowell, *Great Britain: Accounts and Papers* (1833) (450) xx–xxi, *First Report of Commissioners in Manufacturing Districts Relative to the Employment of Children in Factories,* sect. D.1.

[28] A. A. Hargenvilliers (1768–1835), *Recherches et considérations sur la formation et le recrutement de l'armée française* (Paris: Firmin-Didot & Maginel, 1817).

[29] L. R. Villermé (1782–1863), "La taille de l'homme en France," *Annales d'hygiène publique et médicine légale, 1* (1829), 351–400.

[30] Despite kind advice from the keeper of the Archives of Cambridge University (Miss H. E. Peek) these records have not been traced.

[31] A. Quetelet, *Nouveaux Mémoires. . . .* [The title of this journal is now changed to] *Academie Royale des Science des Lettres et des Beaux Arts de Belgique,* 7 (1831–32), 38 pp. Work presented in 1832 published in 1833. Quetelet is sometimes referred to by his full name, Lambert Adolphe Jacques.

[32] A. Quetelet, *Sur l'homme, et le développement de ses facultés* (Paris: Bachelier, 1835).

To understand the importance of the *Treatise on Man* (the English translation appeared in 1842)[33] it is necessary to look at Quetelet's place in the history of statistics.

Adolphe Quetelet drew together the three main statistical developments and tendencies of his time: 1) The method in which verbal analysis and description were used to cover the life and organization of the state. This method originated with the work of Hermann Conring (1606–1681) in the seventeenth century and was continued in the next century by Gottfried Achenwall (1719–1772). 2) The school of "Political Arithmetic" begun by John Graunt (1620–1674) and followed by William Petty (1623–1687). 3) The development of the mathematical theory of probability.[34]

By combining and developing these approaches, Quetelet sought to understand man's situation in his society through the study of the development and general faculties of man himself.

In his *Treatise on Man* Quetelet divided his subject into four sections, with these titles.[35]

BOOK I	Development of the physical qualities of man. The material is concerned with the levels and causes of birth and mortality rates.
BOOK II	Development of stature, weight and strength, etc.
BOOK III	Development of the moral and intellectual qualities of man. Moral qualities were judged to be "Foresight, Temperance, Activity, etc." Intellectual qualities of different populations were compared by such criteria as the age of successful dramatists and the incidence of insanity.
BOOK IV	Of the properties of the average man; of the social system, and of the final advancement of this study.

Previous memoirs are included and developed in this work, and the concept of the average man (*homme moyen*) is clearly put

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[33] *Treatise on Man*, trans. "under the superintendence of Dr. R. Knox" (Edinburgh: W. and R. Chambers, 1842).

[34] Malthus, La Place, and Fourier were all known personally to Quetelet. For Quetelet's contribution to the theory of probability see Helen M. Walker, *Studies in the History of Statistical Method* (Baltimore: Williams and Wilkins, 1929).

[35] Quetelet, *Treatise on Man*, bk. I, p. 9; bk. II, p. 57; bk. III, p. 72; bk. IV, p. 96.

forward. F. F. Hankins, in his "Adolphe Quetelet as Statistitian," [36] suggests that this concept is the unifying principle found throughout the wide range of Quetelet's works on population, moral statistics, physical anthropology, and the social system in general. Through this reiteration, the idea came to be widely disseminated.

Quetelet's concept of the average man changed from that of the early memoirs, which had depended upon direct measurements. Originally he had said:

> The man that I consider here is analogous to the centre of gravity in bodies; he is the mean about which oscillate the social elements; he is, so to speak, a fictitious being for whom all things proceed conformly to the average results obtained for society. If we wish to establish the basis of a social mechanics (*mécanique sociale*), it is he whom we should consider, without stopping to examine particular or anomalous cases.[37]

Later, Quetelet developed the view of the average man as a biological type about which the actual men of a given group were distributed according to the normal law of error, or the "law of accidental causes," as Quetelet called it.[38]

Moleschott, like Quetelet, recognized that the average man could not be constructed as a composite being, and he stressed that his calculations should be applied to the *majority*, for, as he said, we should always remember that "an individual is indeed to some measure an individual just because he does not fit into a line of arithmetical means." [39] Nevertheless, as Moleschott himself had pointed out, it was on the basis of unit of body weight and unit of time that a quantifiable standard of food requirement could be constructed.

B) DIETARIES

Reference has already been made to ration scales. The example shown in Table 2 is from a sixteenth-century "House of Correction."

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[36] F. F. Hankins, "Adolphe Quetelet as Statistitian," *Studies in History, Economics, and Public Law* (New York: Columbia University) *31* (1908), no. 4.

[37] Ibid., p. 63. The translation is by Hankins.

[38] Ibid., p. 67.

[39] Moleschott, *Physiologie*, p. 226.

Table 2 Maximum Daily Allowance per Person[40]

Flesh days

Rye bread	8 oz (troy weight)
Porridge	1 pint
Flesh (unspecified)	¼ lb
Beer	1 pint (quality varied with cost)

Those who worked hard had "a little more" beer and bread between meals. Those who would not work received only beer and bread. From a scale of this type is was impossible to estimate the intake of individuals or groups from over-all figures. The twenty-one dietaries used by Moleschott for his calculations were assumed to be the actual intake of the people involved. Some, such as those of sailors and soldiers, were naturally related to their ration scales. Moleschott's stated object in using figures from a variety or diets was to

> determine empirically and directly how much albuminous matter, fat and fat-formers, salt and water a hard-working man takes in 24 hours if he is not prevented by either need or prejudice from completely satisfying the need for nourishment he feels to be necessary.[41]

It was assumed that the soldiers, sailors, farm workers, peasants, and railway workers taking the foods listed were in the happy position of being able to satisfy their needs. The figures Moleschott used came from the period 1842–1856, and the wide selection of recorded dietaries then available indicates a marked increase in the study of diets in various countries during that period. It is, of course, impossible to pinpoint the reason for this interest, but some of the contributing factors may be indicated under the following headings: (i) Humanitarian; (ii) Practical; and (iii) Scientific, i.e., the effect of the developments in scientific thought and techniques. These headings also cover three factors essential to the general implementation of any new ideas—a suitable climate of opinion, an expediential need, and the availability of proper techniques to do the task.

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[40] From "Orders . . . for the House of Correction at Bury, Suffolk" (1588); see F. E. Eden, *The State of the Poor* (London: J. Davis for B. & J. White, 1797), vol. III, App. cxliii.

[41] Moleschott, *Physiologie*, p. 217.

It will be seen from the examples used by Moleschott that the investigation of diets was taking place in various countries at this time. Here, the illustrative references given have been chosen from a British context.

(i) *Humanitarian factors*

The French Revolution and the impact of such writings as Tom Paine's *The Rights of Man* provided a climate of awareness about the ordinary man and his problems. An indication of the confusion of contemporary thought in the early nineteenth century about the proper action to be taken to help the laboring classes is found in the studies of Sydney and Beatrice Webb and J. R. Poynter.[42] All approaches to the problem necessitated investigation into the conditions of life of the working man.

(ii) *Practical factors*

Consideration of the diets of various groups of the population was forced on the authorities for practical reasons.

The Naval mutiny of 1797 caused far-reaching reforms, among which were changes in naval ration scales. These were altered in 1825 and again in 1844. It was said of the 1844 scale that there could be no "complaint of an insufficiency of food, although the allowance [31–35 oz nutritious matter daily] cannot be regarded as superfluous."[43] Dietary conditions in the Army were brought to the notice of the public through the Crimean War (1854–1856), but earlier the high mortality rate of troops at overseas stations had resulted in a series of reports, such as Marshall and Tulloch's *Statistical report on the Sickness, Mortality and Invaliding among troops in the West Indies* (1838).[44] This was one of many such reports advocating an improvement in Army diet.

At home the high prices of food in 1795 led to the introduction of the Speenhamland System which provided a scale of outdoor relief. This scale was based on the price of bread and the size of the family.[45] Continuing destitution and the rapid rise of the Poor Rate led to the Poor Law Amendment Act of 1834, the basis of which was the abolition of outdoor relief for the able-bodied poor and the concentration of the care of the needy in

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42. S. and B. Webb, *English Poor Law History* (London: F. Cass, 1963), pt. II, vol. I. First edition 1929: J. Poynter, *Society and Pauperism* (London: Routledge & Kegan Paul, 1969).

43. Carpenter, *Human Physiology*, p. 45.

44. Great Britain, Army Medical Services: H. Marshall and A. M. Tulloch, *Statistical Report on the Sickness, Mortality and Invaliding among Troops in the West Indies* (London: W. Clowes, 1838).

45. Webb, *Poor Law History*, pp. 177–178.

Union Workhouses. In 1836 the Poor Law Commissioners suggested six general dietaries (based on past usage) to be used by the guardians for able-bodied men and women in workhouses. The important point underlying the use of these diets was that they must not be better than "the ordinary levels of subsistence of the labouring classes of the district."[46] The need to determine this level of subsistence led to further investigations into the standard of living of laborers and agricultural workers in various parts of the country.

(iii) *Scientific factors*

The important relationship between the development of elementary analysis and the origins of physiological chemistry has been well described by F. L. Holmes.[47] The new techniques of analysis were quickly applied to a wide variety of foodstuffs. In 1816 Francois Magendie had shown that animals could not live on one type of food alone,[48] and a number of other workers in animal nutrition had investigated the nutritive value of different foods. Following Thaer's table of hay-equivalents of 1812, Boussingault produced his *Table of Equivalents,* based on nitrogen content, in 1844.[49] This table gave quantities of different kinds of vegetable foods which, theoretically, would produce the same effects on the growth of muscle in animals. From his work on calculating proper rations for animals, R. D. Thomson, in 1846, emphasized the great importance of the ratio of nitrogenous to nitrogen-free foods in the diet.[50] This ratio, given in terms of the nitrogen and carbon contents of a diet, came to be used for the comparison of the value of different food intakes. By Moleschott's time the techniques available for estimating and comparing the value of different foods had given a new sigficance to the study of dietary intakes.

The dietaries used by Moleschott came from the following authors:[51]

MULDER two examples of soldiers

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[46] Great Britain, Poor Law Commissioners, Edwin Chadwick, *Second Annual Report of the Poor Law Commissioners for England and Wales* (London: W. Clowes, 1836), p. 63.

[47] F. L. Holmes, "Elementary Analysis and the Origins of Physiological Chemistry," *Isis,* 54 (1963), 51–81.

[48] F. Magendie, "Mémoire sur les propriétés nutritives des substances qui ne contiennent pas azote," *Ann. Chim. Phys.,* 3 (1816), 66–77.

[49] J. Boussingault (1802–1887), *Economie rurale* (Paris: Béchet jeune, 1844), p. 483.

[50] R. D. Thomson (1811–1864), *Experimental Researches on the Food of Animals* (London: Longman, 1846), p. 165.

[51] Moleschott, *Physiologie,* p. 218.

PLAYFAIR	eight examples of soldiers, sailors, and agricultural laborers
LIEBIG	one example of soldiers
GASPARIN	one example of a "French worker"
PAYEN	seven examples of a sailor, workers, peasants, handworkers and English railway workers
WUNDT GENTH	self-observations

Comments on Authors and Diets

The dietaries selected by Moleschott came from the works of authors with widely differing backgrounds. Details were rarely given of how the dietary records were collected.

Mulder, G. J. (1802–1880) Dutch physiologist, famous for his theory that there was one radical in albuminous-type materials which he called *proteine*. One-time teacher of Moleschott (who translated some of his works into German), Mulder's reference to the diet of Dutch soldiers was incidental to his discussion of the value of foods.[52]

Playfair, Lyon (1819–1898), one-time pupil of Liebig; Secretary to the Department of Science and Arts in Britain; later Professor of Chemistry in Edinburgh and Member of Parliament. The figures used were taken from his paper entitled "The Food of Man under Different Conditions of Age and Employment," given at the Royal Institution in 1853.[53] From this article Moleschott used records of English, French, and Bavarian soldiers, and English sailors under various conditions.

Liebig, Justus von (1803–1873). Details of the diet of Hessian soldiers were given in his *Animal Chemistry*. Accurate observations were made, for a month, on the food intake of 27–30 soldiers in barracks. The quantity of food taken outside was given in "an approximate" report by the sergeant-major. The total intake of food was added up, and this quantity was taken as the daily intake for 855 men. Moleschott's figures were taken from this total as the average per man per day.[54]

Gasparin, A. E. P. de (1783–1862), French authority on

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[52] G. J. Mulder, *Die Ernährung in ihrem Zusammenhange mit dem Volksgeist* (Utrecht, Düsseldorf: Böttischer, 1847), p. 59.

[53] Lyon Playfair, "The Food of Man under Different Conditions of Age and Employment," *Proc. Roy. Inst. of G. Brit., 1* (1853), 313–317.

[54] Liebig, *Animal Chemistry*, pp. 285–289.

agriculture, author of the famous *Cours d'agriculture, 1843–1860*[55] Gasparin wished to relate food intake to work done and used figures from Quetelet and Villermé to do this. Details of the diets of agricultural workers were placed under the section on Farm Management in the part dealing with Capital Investment. Under this heading Gasparin included items related to the health and working ability of men and beasts.

PAYEN, ANSELM (1795–1871) French industrial chemist of high repute. The diets were taken from *Des substances alimentaires*.[56] Here Payen records and comments on diets taken from a number of sources including Gasparin's *Cours d'agriculture*. One of particular interest is that of the English railway workers who were working on the Rouen railway.[57] Their larger daily ration of meat was thought to account for the fact that they did so much more work than their French counterparts. This comparison was frequently quoted by later writers to illustrate the importance of meat in the diet when doing hard work.

GENTH, A. E., was a physician at the Spa at Wiesbaden. The information about his diet came from his study of the effects of drinking water.[58]

WUNDT. This individual has not yet been definitely identified, but he may have been a student at Heidelberg in Moleschott's time.

Moleschott did not, himself, record any diets for the purpose of his calculations, and obviously the dietaries he used had not been designed for that purpose. The records he chose contained the information he needed for his calculations, though no single diet provided information on all the points that interested him. These points were:

The total weight of nitrogenous material eaten:	figures available from all diets
The total nitrogen-free material (fat and carbohydrate):	from 13 diets

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[55] A. E .P. de Gasparin, *Cours d'Agriculture* (Paris: Maison Rustique, 1843–1860), V, 387–398; and see also III, 51.

[56] A. Payen, *Des substances alimentaires* (Paris: Hachette, 1853), pp. 339–386.

[57] Ibid., p. 376.

[58] E. A. Genth, *Untersuchungen euber den Einfluss des Wassertrinkens auf den Stoffwechsel, nebst einigen Bemerkungen, betreffend die in der Wasserheilanstalt Nerothal übliche Verbindung der Bewegungs-Heilmethode mit Wassercur* (Wiesbaden: Kreidel & Niedner, 1856).

The ratio of nitrogenous to nitrogen-free foods:	from 13 diets
The ratio of fat to fat-formers:	from Wundt and Genth
Salt intake:	from 13 diets

The total water was calculated from excretion figures. Moleschott wished to relate his findings back to his "reference man" of 63.65 kg, but of all the diets he used, only those from Gasparin and Genth were given in relation to body weight.

The diets of Moleschott used were for the most part chosen from the publications of well-known men. These were, in fact, only a small part of those records available in the 1850s. Moleschott does not, for example, refer to *Die Normal-Diät* by W. Hildesheim, published in Berlin in 1856,[59] in which the author attempts to determine a normal diet through an examination of metabolic studies and dietary intakes.

C) BALANCE STUDIES

Moleschott checked the suitability of these dietary intakes against the matter excreted by his "reference man" in 24 hours. He recognized that this method would give a low figure for food intake because it was not possible to measure accurately all body losses. His method was based on the belief that for a normal, healthy adult output is equivalent to intake. A proper balance between the intake and excretions of the body was a fundamental part of many theories of health, and a study of this balance has long been used to investigate metabolic processes.

The first precise measurement we have of intake related to output is that of Sanctorius (1561–1636). Sanctorius worked in Padua and for more than thirty years studied the weight of insensible perspiration (including vapor lost from the lungs) in relation to the six non-naturals. His findings are found in "Aphorisms" in the *Medicina Statica.*[60] Dr. James Keill (1673–1719) of Northampton did a similar study in the English climate. His results are published, together with John Quincy's translation of

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[59] W. Hildesheim, *Die Normal-Diät; Physiologisch-chemischer versuch zur Ermittelung des Normalen Nahrungsbedüfnisses der Menschen, behufs Aufstellung einer Normal-Diät* (Berlin: Hirschwald, 1856).

[60] Sanctorius' *Medicina Statica* was a familiar work. It had been 'Englished' by J(ohn) D(avis) in 1676 (London: J. Starkey)and was commented on by Martin Lister: *S. Sanctorii de Statica Medicina . . . cum Commentario* (London: Smith & Walford, 1701).

Sanctorius' Aphorisms, in *Medicina Statica Britannica* of 1728.[61] Among Keill's sixty-six aphorisms are these:

APH. 8 "In a most healthful state the Quantity ejected is equal to the Quantity taken in."

APH. 40 "The natural Discharges are not in proportion to the weight of the Body, but the Quantity of Diet taken in."

APH. 43 "If the Quantity of food be greater or lesser than needful, then it will not answer to the Quantities evacuated: for whether we eat more or less, Nature always keeps a certain Rule in Evacuation." [62]

Despite the recognition of this last rule, excretions were still considered to be in proportion to intake because, it was said, "the rule admits wide latitude" and, in any case, depended on the powers of digestion.[63]

The relationship between the weights of food intake and excretions was confirmed some ten years later in Bryan Robinson's *Dissertation on the Food and Discharges of the Human Body*,[64] in which the author combined his own results with Keill's and with material from George Rye's *Medicina Statica Hibernica* (1734)[65] and the reports of John Lining of South Carolina (1708–1760).[66] All their figures show that the weight of food taken about equals the weight of excretions. Robinson believed that the quantity of material discharged was governed by the motion of the blood. In Proposition II he writes:

> The sum of the Discharges by Perspiration (p), Urine (u), and stool(s), in a Natural day or any other Time, is nearly proportional to the mean Quantity of Blood, which in that Time flows out of the Heart into the Aorta in one Systole (q), and the Number of Systoles or Pukes in the same Time taken together (N).

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[61] John Quincy (d. 1722), *Medicina Statica Britannica*, 4th ed. (London: Osborne & Longman, 1728).

[62] Ibid., p. 323, 335, 336.

[63] Ibid., p. 337. The concept of homeostasis was developed from the work of Claude Bernard and introduced in the twentieth century by Walter B. Cannon in *The Wisdom of the Human Body* (New York: W. W. Norton, 1932), p. 24.

[64] Bryan Robinson (born 1679) *A Dissertation on the Food and Discharges of Human Bodies* (London: J. Nourse, 1748).

[65] George Rye, "Medica Statica Hibernica" can be found as the second part (p. 189 et seq.) of Joseph Rogers' *An Essay on Epidemic Diseases . . .* (Dublin: printed by S. Powell for W. Smith, 1734).

[66] Lining's results were published in *Phil. Trans. Roy. Soc.* 42 (1743), 491–509; 43 (1745), 318–330.

And he gives the formula,

$$p + u + s \text{ is nearly proportional to } qN$$[67]

Robinson's primary concern was with the quantity of material taken in and excreted. Later workers took somewhat different approaches. William Cruickshank, for example, was concerned with the composition as well as with the quantity of insensible perspiration. He first published his *Experiments on the Insensible Perspiration of the Human Body showing its Affinity to Respiration* in 1779 and republished it in 1795.[68] He believed that the skin could absorb and excrete "air," and he thought that the composition of insensible perspiration was similar in effect to expired air—a point over which he came into collision with Priestley.

In the early nineteenth century it was known that if excreted matter was to be related to intake in terms of *quality* as well as quantity the connection should be through the chemical elements of nitrogen, carbon, hydrogen, and oxygen, and at that time much experimental research was done along these lines. The analysis of urine, sweat, and feces done by Berzelius in 1806 remained a standard for many years, being commended in 1820 by Thomas Thomson (1773–1859)[69] and by later writers such as C. G. Lehmann in his *Physiological Chemistry*.[70] Regarding excretion through the lungs, the work of Allen and Pepys on human respiration, published in 1809, is particularly notable.[71] But before elemental intake could be equated with output, the idea that elements could be produced during metabolism had to be discarded. In 1799 L. N. Vauquelin had demonstrated by experiment that the hen could generate calcium.[72] In 1838 Thomas Thomson had been uncertain that fixed principles were produced by growing plants,[73] and by 1843 Pereira still felt it was necessary to make the point, more than once, that "a living body has no power of forming elements, or of converting one

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[67] Robinson, *Food and Discharges*, p. 28.

[68] William Cruikshank (1745–1800), *Experiments on the Insensible Perspiration of the Human Body showing its Affinity to Respiration*, first published with other material in 1779, "republished with additions and corrections," 1795, (London: printed for G. Nicol).

[69] Thomas Thomson, *A System of Chemistry*, 6th ed. (London: Baldwin, Craddock & Joy, 1820), IV, 536, 539, 553.

[70] Translated by G. E. Day from the German edition of 1850 (London: Cavendish Society, 1851–1854), II, 384.

[71] W. Allen and W. H. Pepys, *Phil. Trans. Roy. Soc.*, 2 (1809), 404–429.

[72] L. N. Vauquelin (1763–1829), *Ann. Chim.* 29 (1799 or An. VII), 3–26.

[73] T. Thomson, *Chemistry of Organic Vegetables* (London: Baillière, 1838), p. 972.

elementary substance into another."[74] For some time thereafter the definition and theory of chemical elements and the question of their immutability remained subjects for controversy.[75] As far as human metabolic balance studies were concerned, by Moleschott's time is was generally accepted that the elements in the body must have been obtained from outside the body, the obvious source being food. This still left the question of whether atmospheric nitrogen could be used by the body and would appear in nitrogen balance results. Though Boussingault's work on "metamorphosis" in 1844 had shown that atmospheric nitrogen was not used by animals as a food,[76] the subject continued to be controversial. It might have been hoped that the use of more precise techniques at this time would have lessened the likelihood of controversy. Far from it. One gains the impression that there can hardly have been a chemist of note who did not study some aspect of bodily excretion, nor a substance discovered which did not cause a verbal as well as a chemical reaction.

During the 1850s research into metabolism included a large number of investigations of the volume and quality of body losses under normal and abnormal conditions. E. A. Parkes collected many of these results in his book on *The Urine* (1860).[77] From a comparison of reports it was clear that even under normal conditions wide variations in results were possible. Nevertheless Moleschott used results of urine analysis as the base of his calculation of food intake from excretions. He took his figures from the results of ten researchers, including such well-known workers as Scharling, Barral, and Bischoff,[78] adjusting their figures for his "reference man" as shown in the accompanying Table 3.[79]

He derived his calculations of food intake from the quantity of nitrogen excreted. Most of this nitrogen was in the urea, and the basis of his calculation was the relationship of urea to nitrogen intake. Some research workers believed that urea came in part from the breakdown of tissues and that part could also be formed from nitrogen in the food. Moleschott, like Liebig and Bischoff, belonged to the school of thought that believed urea to

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[74] *Food and Diet*, pp. 4, 468.

[75] See David M. Knight, *Atoms and Elements, a Study of Theories of Matter in England in the Nineteenth Century* (London: Hutchison, 1967).

[76] J. B. Boussingault, *Ann. Chim. Phys.*, *12* (1844), 153–167.

[77] E. A. Parkes (1819–1876), *The Composition of the Urine in Health and Disease under the Action of Remedies* (London: Churchill, 1860).

[78] Moleschott, *Physiologie*, p. 58, Table LXX. References are to Scharling, Barral, Bischoff, Sherer, Rummel, Mosler, Hammond, von Franque, Kaup, and Schneller. Here the figure for uric acid is given as 0.61.

[79] Ibid., p. 221.

Table 3 The Amount of Nitrogen, Carbon and Hydrogen in the Most Important Elements of Excretion

Amount of matter in question for a body-weight of 63.65 kg in 24 hours	Grams	Contained therein N	C	H
Urea	31.3	14.60	6.26	2.08
Uric acid	0.31	0.20	0.21	0.01
Urinary pigment	7.79	0.69	4.55	0.40[a]
Carbonic acid	963.29		263.56	
Water	3119.78			346.64
		15.49	274.58	349.13

[a]Calculated according to Scherer's analysis.

be solely a product of the metamorphosis of nitrogenous tissues.[80] From this point of view the nitrogen excreted in the urine could be taken to represent the nitrogen required by the body for the replacement of tissues, and therefore could also represent the required nitrogen intake from food in twenty-four hours. In the middle of the nineteenth century workers accepted the fact that the nitrogen balance of the body was not understood. The much-quoted work of C. Chossat[81] on metabolism during inanition (1842) and the massive researches reported by Bidder and Schmidt in their *Die Verdauungssaefte und der Stoffwechsel* (1852)[82] had given clues to the true situation regarding nitrogen balance: that is, that within limits the normal adult body adjusts its nitrogen output to intake, but equilibrium is not reached immediately when a change of intake occurs. Nitrogen balance figures continued in use for estimating protein needs until very recently.[83] Moleschott's calculations assumed equilibrium.

Using figures shown in Table 3 and Mulder's estimate that there was 15.5 percent nitrogen in albumin, Moleschott said that the nitrogen excreted (15.49 g), was equivalent to 100 g albumin. By subtracting the carbon present in this quantity

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[80] See G. E. Day (1815–1872), *Chemistry in Relation to Physiology and Medicine* (London. Baillière, 1860), pp. 37–49.

[81] C. Chossat (1796–1875), "Recherches expérimentales sur l'inanition," *Annales des Sciences naturelles* (Zoologie), *20*, (1843), 55–81, 182–214, 293–326.

[82] F. Bidder (1810–1894) and C. Schmidt, *Die Verdauungssaefte und der Stoffwechsel* (Mitau, Leipzig: G. A. Reyher, 1852).

[83] The latest (7th) revision (1968) of the U.S.A. N.R.C. *Recommended Dietary Allowances* is the first to discard the nitrogen equilibrium method for estimating protein needs of adults and children over one year.

of albumin he was left with the carbon present in nitrogen-free foods. Arbitrarily selecting starch and margarine[84] as representative of the two nitrogen-free groups, Moleschott used their formulae, the ratio of fat to starch (1:4.84) from the dietaries referred to above and, making adjustments for respiration, calculated the amount of starch, fat and water taken in. He found by this method that the calculated total food intake was approximately the same as the dietary average: 3.818 kg compared with 3.448 kg. He took the similarity of the two results to be "the best proof that the food requirements we have given, as sufficient for a working man, are not exaggerated."[85] This emphasis on the fact that the quantities he had advocated for a working man were not too large is found throughout his work. By comparing "active," "resting," and "subsistence" figures,[86] Moleschott underlined the need of an active man for more than a minimal allowance.

It may have been his emphatic belief in the necessity of proper nourishment for a man to work and a woman to feed her children which led him to formulate his standard. Moleschott himself gave no direct explanation, either in his Preface or in the relevant chapter of *Physiologie,* as to why he wished to show, against contrary opinion, that such a standard could be set up, but his approach would have been derived both from his work and from his philosophy. Moleschott's physiological investigations covered a wide field, including work on the kidney, blood, and respiration. The use he made of the many tables given in his publications illustrate the importance he placed on scientific measurement in nutritional work—an attitude he would have met when he worked briefly in Mulder's laboratory (1845)[87] after taking his M.D. degree at Heidelberg. Returning to teach at Heidelberg in 1847, he did not confine his interests to laboratory research but included the study of man as a whole in his lectures. He was particularly concerned with the causes (chemi-

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[84] Margarine (margaric acid) was discovered by M. E. Chevreul in 1813. In 1855 W. H. Heintz described it as a mixture of palmitin and stearin.

[85] Moleschott, *Physiologie,* p. 224.

[86] Moleschott, *Physiologie,* p. 225. The "resting" figure was obtained from reports by Playfair on the diet of English and Bengalese prisoners (see n. 63 above). The "subsistence" figure (40 g albuminous material) was considered to be of interest only to scientists and perhaps those shipwrecked or beseiged.

[87] See W. Moser, *Der Physiologe Jakob Moleschott (1822–1893) und seine Philosophie, Zürcher Medizingeschichtliche Abhandlungen,* Neu Reihe 43 (Zürich: Juris-Verlag, 1967).

cal and physical) rather than the reason (theological and philosophical) of man's being. The strength of these materialistic views caused such opposition that he was forced to leave Germany, and it is for his views in the philosophy of materialism[88] rather than for his work in physiology that Moleschott is remembered today. His friend Ludwig Feuerbach, discussing Moleschott's *Lehre der Narungsmittel für das Volk* (1850),[89] summed up the content of the book with the oft-quoted comment: "der Mensh ist was er isst,"[90] "man is what he eats." It was in this book that Moleschott made his most controversial and most quoted statement, namely, "Ohne Phospher kein Gedanke,"[91] though these words have in fact been attributed to a variety of other authors, including Liebig.[92] It can be seen that within the framework of his strong materialistic philosophy, the importance of a proper diet for the health, happiness, and fulfillment of man must have had a particular significance for Moleschott.

As already noted, Moleschott was not alone in his attempts to quantify dietary needs. Several examples of similar approaches may be cited: Gasparin had pointed out the importance of both parts—the *ration d'entretien* and *ration de travail*—in a proper diet, when discussing the work of a farm laborer;[93] the work of Hildesheim, already referred to; I. Leitch, in "The Evolution of Dietary Standards" written in 1942,[94] commented particularly upon the standard set by Dr. Edward Smith[95] in his report on the Lancashire Cotton Famine of 1862;[96] the famous

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[88] Moleschott had eighteen references in the index of F. A. Lange *The History of Materialism and Criticism of Its Present Importance,* trans. E. C. Thomas, 3rd ed. (London: Kegan, Paul, Trench, Trubner & Co., 1925), three volumes in one. (1st German ed., 1865.)

[89] J. Moleschott, *Lehre der Nahrungsmittel fur das Volk* (Erlangen: F. Enke, 1850). The book itself gives Erlangen as place of publication; some bibliographies quote Stuttgart.

[90] Moser, *Moleschott,* p. 18.

[91] Moleschott, *Lehre der Nahrungsmittel,* p. 116.

[92] J. Liebig, *Principles of Agricultural Chemistry with Special Reference to the Late Researches Made in England,* trans. W. Gregory (London: Walton & Maberly, 1855), p. 49n.

[93] Gasparin, in *Cours d'agriculture,* V, 390, suggested a total of 25.01 g nitrogen and 309.0 g carbon for a man weighing 62.541 kg.

[94] *Nutrition Abstracts and Reviews, 11* (1942), 509–521.

[95] Great Britain, Public Health, *Fifth Report of the Medical Officer of the Privy Council* (London: Eyre & Spottiswoode, 1863), App. V, pt. 3 (Edward Smith, "Nourishment of the Distressed Operatives"), pp. 320–456.

[96] Edward Smith (1818–1874) advocated 200 grains of nitrogen and 4,000 grains of carbon for a man's body weight of 150 lb (1 oz avoir = 437.5 grains).

physiologist Karl Vierordt also provided quantities for required dietary intake.[97]

Of the figures available then as well as later, Moleschott's standard was the one most widely quoted. The reasons for this selection would seem to be due to the authority of the author in the subject, the place of publication, and the method of presentation. Though Moser suggests that Moleschott, in his own time, was counted in the second rank of scientists (partly perhaps through disapproval of his philosophy),[98] the influential English writers E. A. Parkes, and G. E. Day, in 1864, described him, in relation to nutrition, as "the greatest authority at present" and "a well-known German [sic] authority on dietetics."[99] Moreover, Moleschott's standard was published in a book dealing specifically with nutrition. The figures of Gasparin, Smith, and Vierordt appeared in works of a different character.

In the large number and wide range of his publications[100] Moleschott succeeded in his aim of describing the newest discoveries simply and clearly, so that they were comprehensible to an audience beyond just those who specialized in the subject. In contrast Hildersheim's work, though quoted by Parkes,[101] required a persistent student to work through the tables, which had the weights given in "loths" to the fourth decimal place.[102]

The continued reference to Moleschott's "numbers" in textbooks will have been influenced by the usual habit of repetition and by the respect and affection in which Moleschott was held until the end of his life. Moser[103] refers to the greetings Moleschott received on his seventieth birthday (1892) from the most important men in Europe. The tributes paid him at that time by his Italian colleagues were published after his death in a translation of his autobiography.[104]

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[97] K. Vierordt (1818–1884), *Der Physiologie des Menschen* (Frankfurt A.M.: Meidinger Sohn & Co., 1860), p. 192.

[98] Moser, *Moleschott,* p. 7.

[99] E. A. Parkes, *A Manual of Practical Hygiene Prepared Especially for Use in the Medical Service of the Army* (London: Churchill & Sons, 1864), p. 139. G. E. Day, *Chemistry in Relation to Physiology,* p. 514.

[100] See Moleschott's *Untersuchungen zur Naturlehre des Menschen und der Thiere,* ed. G. Colasanti & S. Fubini (Giessen: E. Roth, 1895), vol. XV, pt. I, pp. 12–20.

[101] Parkes, *Manual of Hygiene,* p. 139. Here Hildesheim's figures are given in "ounces avoir" as: albuminates 4.64, fat 1.3, starches 16.8.

[102] One Loth = approx. 1/32 – 1/30 of an ounce. The value varied at different times.

[103] Moser, *Moleschott,* p. 27.

[104] Elsa Patrizi-Moleschott (trans.), *Jacopo Moleschott, Per gli amici miei: Ricordi autobiografici* (Milan, Palermo, Naples: Remo Sandron, 1902), pp. 291–350. Tributes came from D'Annunzio, A. Mosso, C. Lombroso, and P. Giacosa.

Finally, it is of interest to see how Moleschott's standard was used in the subsequent years of the century. Referring in 1862 to the calculations of requirements, the German physiologist Garup-Besanez commented that though Moleschott's calculations were based on partly unsure and variable data it should still give some idea of the actual state of affairs.[105] After further detailed comment on Moleschott's chapter, Garup-Besanez stressed that the calculations were valid only as far as they had been made on the results of a large number of people and were not applicable to individual cases. The writer, like others at that time, then concentrated on what the figures meant in terms of foods to be eaten.[106] This type of approach is also found in Pavy's *Treatise on Food and Diet*[107] of 1874 where specific reference is made to Moleschott's standard. For some workers the results of Ranke's experiment on himself[108] supplanted Moleschott's figures. Michael Foster, in his *Textbook of Physiology* (1878), quoted both Moleschott (inaccurately) and Ranke as follows:[109]

	Moleschott	*Ranke* (wt 74 kilos)
Proteids	30[a] [sic]	100
Fat	84	100
Amyloids	404	240
Salts	30	25
Water	2800	2600

[a]Should read 130 g. No units were given by Foster.

Here the weight of Moleschott's "reference man" was omitted, though Ranke's weight was given. Foster compared the two standards in the following terms:

> Of these two diets, which agree in many respects, that of Ranke is probably the better one, since in public diets, from which Moleschott's table is drawn, the cheaper carbohydrates are used to the exclusion of the dearer fats.

[105] E. F. von Garup-Besanez (1817–1878), *Lehrbuch der Physiologischen Chemie* (Braunscweig: F. Vieweg & Son, 1862), pp. 749–751.

[106] The characteristic modern approach of concentrating on the quantity of nutrients required without any immediate reference to foodstuffs was a later and a gradual development.

[107] F. W. Pavy (1829–1911), *A Treatise on Food and Dietetics* (London: J. & A. Churchill, 1874), p. 452.

[108] J. Ranke (1836–1916), *Grundzüge der Physiologie des Menschen* (Leipzig: W. Englemann, 1868), p. 158.

[109] M. Foster (1836–1907), *A Textbook of Physiology* (London: Macmillan, 1878), p. 358. (1st ed., 1877).

In the fourth edition of Foster's *Textbook* (1884), he quoted the same figures (with Moleschott's proteids corrected), but under the headings "Public diet (Moleschott)" and "Ranke."[110] In the fifth edition (1891) reference was made simply to diets 'A' and 'B,' with diet 'A' the same as Ranke's standard. In each case the energy value in calories had been calculated.[111]

Despite the growing emphasis, at the turn of the century, on the energy value and mineral content, as well as the protein value, of diets, Moleschott's figures were still referred to by workers in many countries. In the United States, W. Gilman Thompson, in his *Practical Dietetics* of 1896, quoted Moleschott's standard in comparison with those of Pettenkofer (1819–1901) and Voit (1831–1908), Ranke, Playfair, Foster, Landois (1837–1902), and Dujardin-Beaumetz (1833–1895),[112] as well as referring to the quantity of "dry food" (23oz) advocated by Moleschott. This information was given in conjunction with advice from Letheby and Pavy.[113] The Frenchman Cathelineau and Lebrasseur, in *Hygiène et régimes alimentaires* of 1897, worked from the *ration d'entretien* of Voit and Pettenkofer,[114] Moleschott's figures being given as a standard of comparison for soldiers' diets.[115] Reference has already been made to the inclusion of Moleschott's figures in the table of standards given in the 1933 edition (9th) of Hutchinson's *Food and the Principles of Dietetics*. The table appears in the first nine editions of the work and includes the standards of Rubner and Atwater,[116] the leading workers in the field of human energy metabolism. In the 1930s this type of table disappeared, taking Moleschott's figures with it. The modern approach was developing. A number of national standards were put forward,[117] and in the mid-thirties the League of Nations attempted to collect information on nutritional conditions in many countries and formulated a general average standard in terms of energy, protein, calcium, and iron, pub-

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[110] Foster, *Physiology*, 4th ed. (1884), p. 446.

[111] Foster, *Physiology*, 5th ed. (1891), II, 833.

[112] W. Gilman Thompson, *Practical Dietetics: with Special Reference to Diet in Disease* (New York: Appleton & Co., 1896), p. 264.

[113] Ibid., p. 269.

[114] H. Cathelineau and A. Lebrasseur, *Hygiène et régimes alimentaires* (Paris: Rueff & Cie, 1897), p. 131.

[115] Ibid., p. 173.

[116] Max Rubner (1854–1932), W. O. Atwater (1844–1907).

[117] Examples are the Report of the Committee on Nutrition of the British Medical Association and H. K. Stiebling's figures (U.S. Department of Agriculture, Miscellaneous Publication no. 183), both published in 1933; also the Canadian Council on Nutrition's figures of 1939.

lishing reports in 1936 and 1938.[118] The impact of the Second World War, together with rapid advances in nutritional knowledge led the U.S. Food and Nutrition Board to prepare, in 1941,[119] a carefully considered standard of dietary allowances built up from the specialized knowledge of many experts and providing a standard in terms of calories, protein, minerals, and vitamins for groups of the population according to age, sex, and activity. This "expert committee"approach is the one now favored for the preparation of national and international dietary standards. However, it was not until the first report of the United Nations Food and Agriculture Organization on *Calorie Requirements*,[120] published in 1950, that a generally accepted standard was once more related to the body-weight of a reference man (and reference woman).

When judging the importance of Moleschott's standard it is apparent from the lack of both contemporary and later comment that the significance of his method of calculation was overlooked. Nor can the number and long sequence of references to his figures be taken as a measure of their influence for, as we have seen, they were quoted uncritically, often inaccurately, and usually without any reference to the fundamental basis that Moleschott himself had laid down—i.e., the relation of food intake to the unit of body-weight and unit of time. Nevertheless, the standard was important for it was presented by a recognized authority at a time when the changing attitude toward quantification with respect to the health of the public[121] permitted the acceptance of a quantified dietary standard. It provided a guide and a first stone for the foundation on which are formulated the nutritional needs of the world's population today.

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[118] League of Nations, Report of the Technical Commission on Nutrition, *Quarterly Bulletin of the Health Organization,* 5 (1936), 391–570; 7 (1938), 460–502.

[119] U.S. National Research Council, *Recommended Dietary Allowances* (Washington, D.C.: National Academy of Sciences, 1943).

[120] United Nations, Food and Agriculture Organization, *Calorie Requirements,* F.A.O. Nutritional Studies, no. 5, 1950.

[121] This subject has been discussed by G. Rosen, "Problems in the Application of Statistical Analysis to to Questions of Health," *Bulletin of the History of Medicine,* 29 (1955), 27–45, and R. H. Shryock, "The History of Quantification in Medicine," *Isis,* 52 (1961), 215–237.