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978-0-521-45209-0 - Protein and Energy: A Study of Changing Ideas in Nutrition
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Excerpt
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1 Nutritional Science before the Chemical Revolution, 1614–1773

THE OBJECT OF THIS BOOK is to trace the origins of and changing ideas about the role of protein in our diet and the quantities needed for optimal health. The word "protein" was not coined until 1838, and the chemistry of materials falling into this class was only beginning to be understood in the preceding 40 years. However, scholars were interested much earlier than this in the basic question of whether animals (and humans) had the power to turn any kind of digestible food into the material of their own tissues, or only certain fractions of it, having basically similar properties. There were also differences of opinion as to whether growth in the young, and tissue replacement in adults, was the *sole,* or even the *major,* function of nutrition.

In classical Greek medicine in particular, "diet" was an important consideration in the maintenance of health, although at that time the word meant the whole manner of one's life and environment, as well as one's food.[1] In the second century A.D., Galen had written: "Our bodies are dissipated by the transpiration that takes place through the pores in our skin that are invisible to us; therefore we need food, in a quantity proportionate to the quantity transpired."[2] Foods were classified primarily according to what were thought to be their immediate effects on a person's mood. One food would be sedative, another aphrodisiac, and so on.[3] Different fōods were recommended for people with different temperaments (hot, cold, dry, moist) in order to bring them more into the norm or "ideal" balance.[4]

Recommendations originally made in the classical period were still being proposed in the sixteenth century. Persons of the choleric type were advised

1. Trémolieres (1975); Fidanza (1979).
2. Cited by Temkin (1960), p. 86.
3. Cosman (1983); Mauron (1986).
4. Eliot (1541).

to eat coarse meat (such as beef rather than chicken), which was only slowly digested, and to have frequent meals; otherwise, the intense heat of their digestive system would scorch and damage the empty stomach, with the fumes rising to cause a headache. By contrast, naturally melancholic persons should eat moist and easily digested, boiled meats and should drink milk.[5] These ideas seem strange and incoherent to the modern reader, but they were in fact built up from a complex framework of assumptions.[6]

The New Beginning

There is little connection between traditional belief and the science of nutrition that was stirring in the seventeenth century on the basis of new developments in physical science and physiology. The first influential publication in this period came from the Italian scientist Santorio (usually known by his latinized name, Sanctorius). He was a professor in Padua, the seat of a famous university but best known to English-speaking people from Shakespeare's references to it in the *Merchant of Venice* and the *Taming of the Shrew*, which were written about the time that Santorio was studying there. Santorio repeatedly weighed his food and drink, on the one hand, and his excreta (urine and feces), on the other, and also measured changes in his own weight. He reported in 1614 that, on average, his daily intake amounted to about 8 lb. and his excreta only to about 3 lb. Since there was no significant change in his weight, there was an unexplained daily disappearance of some 5 lb. of material. At that time respiration was thought to serve only as a means of cooling the heart. And since it seemed that this amount of food and drink was necessary, Santorio concluded, for want of any other explanation, that the daily "disappearance" must be due to the breakdown of this amount of body tissue, which was then excreted largely through the skin in the form of "insensible perspiration." The losses were made good by the nourishment ingested.[7] This was only a more quantitative restatement of Galen's view in the 2nd century A.D., but Santorio's work made a great impression.

The second significant advance was published in 1628 by William Harvey, an Englishman who had obtained his medical degree at Padua. This was the discovery of the circulation of the blood from the left side of the heart throughout the body, via arteries, capillaries, and veins and back to the right side of the heart, with a second circulation to the lungs. Harvey's demonstration of a constant, rapid perfusion of the body's tissues by arterial

5. Boorde (1567).
6. O'Hara May (1977).
7. Santorio (1614); Bylebyl (1977), pp. 377–8.

blood provided a mechanism to explain the extensive movements of old material away from the tissues and the incorporation of new.[8]

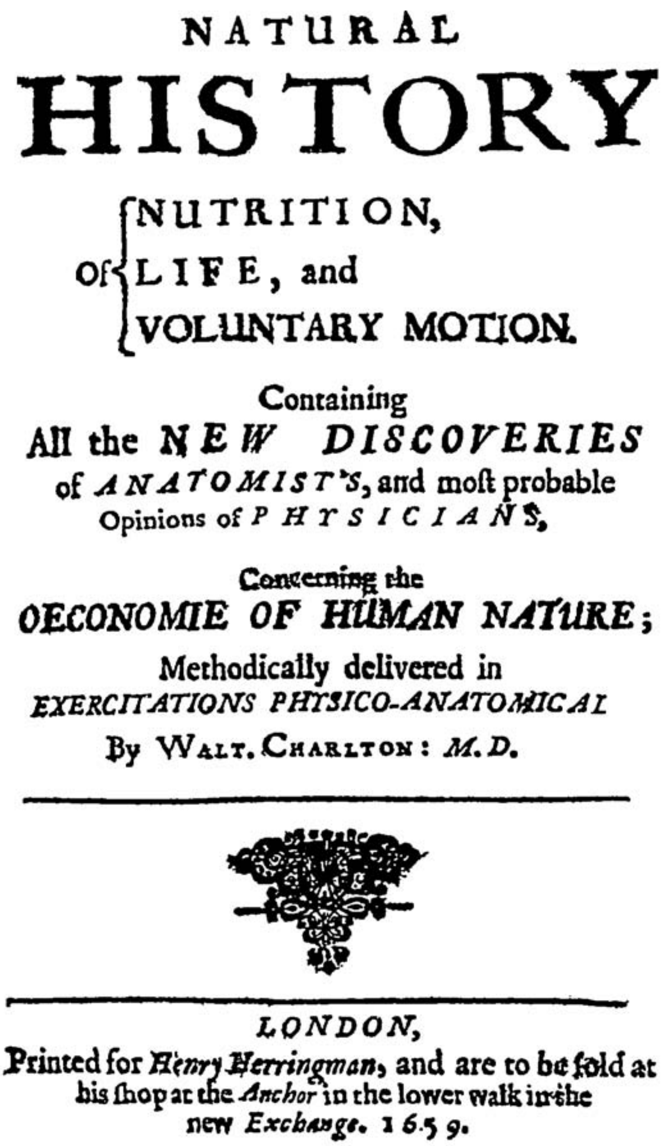
The French philosopher René Descartes, in his *Discourse on Method,* first published in 1637 and still regarded as one of the seminal works in the development of scientific thinking, made use of Harvey's finding. He believed that the living heart was extremely hot and argued that it was the repeated exposure (perhaps 100 to 200 times per day) of absorbed nutrients circulating in the blood to this "hot spot" that gradually "distilled" them into the "stuff" of animal tissues. The process might take longer with some foods than others, but all would eventually be converted.[9] This was not a totally original concept, as has been shown elsewhere.[10]

We see a somewhat different view in *The Natural History of Nutrition, Life and Voluntary Motion,* published in 1659 and considered the first book on human physiology to have been written in English (Figure 1.1). The author, Walter Charleton, born in 1620, was exposed to the new ideas of Harvey, Descartes and others as a student at Oxford, where he earned an M.D. degree. He was a fluent writer, in particular trying to explain recent scientific discoveries and to reconcile them with Christianity, but his career had its ups and downs. He sided with the royalists and remained in Oxford when the English civil war began in 1642 and, while still in his early twenties, became one of the king's personal physicians. After the restoration of Charles II, he became a founding member of the Royal Society and president of the Society of Physicians.[11]

In his book on nutrition, Charleton wrote that animal heat continually agitates the minute particles of the body and "dissolves, dispenses or consumes" them, so that there must be a continuous assimilation of equivalent particles from our food. That is the first function of nutrition. The second is to provide fuel (or oil) for the vital flame burning within us, which can be extinguished either by suffocation or by want of sustenance.[12] This seems consistent with the modern view that, as adults, we need food partly for "maintenance" due to constant wear and tear, or turnover, of our tissues and partly for combustion as a source of energy and secondarily of heat.

Charleton went on to say that he did not believe that the different parts of the body needed correspondingly different materials for their restitution. He believed that a principle similar to that found in the white of an egg would be suitable for all, and he used the simile of a common rain supporting the growth of trees of different species.[13] (At that time, before the existence

8. Debus (1978), pp. 66–73.
9. Descartes (1649), p. 79.
10. Mendelsohn (1964); Hall (1969).
11. Rolleston (1940); Gelbart (1971); Fleitmann (1986).
12. Charleton (1659), p. 10.
13. Ibid., p. 9.



NATURAL
HISTORY
Of NUTRITION, LIFE, and VOLUNTARY MOTION.
Containing
All the *NEW DISCOVERIES*
of *ANATOMIST'S*, and moſt probable
Opinions of *PHYSICIANS*,
Concerning the
OECONOMIE OF HUMAN NATURE;
Methodically delivered in
EXERCITATIONS PHYSICO-ANATOMICAL
By WALT. CHARLTON: *M.D.*

LONDON,
Printed for *Henry Herringman*, and are to be ſold at
his ſhop at the *Anchor* in the lower walk in the
new *Exchange*. 1659.

Figure 1.1. The title page of what appears to have been the first book on nutrition in English. (The author's name is more commonly spelled "Charleton" but here the "e" is omitted.) (Bancroft Library, University of California, Berkeley)

of carbon dioxide in the air had been discovered, it was thought that rainwater actually provided the "substance" of trees.)

He further thought that, after the food had been worked on in the acid conditions of the stomach, the usable portions were divided up according to their function – the fuel going into the blood for its distribution, and the "restorative principle," or *succus nutritius,* being circulated by another route, which he thought must be the nerve fibers.[14] Fifteen years later, John Mayow expanded this concept in relation to rickets, acknowledging that the idea originally came from the Cambridge professor Francis Glisson. His argument, paraphrased, was as follows: In this disease the child's head appears unusually large but the legs weak and poorly developed. The size of the head shows that there can be nothing wrong with the blood, which is the same wherever it circulates. The only other fibers going to the legs are the nerves. There must therefore be some blockage in the spinal tract which hinders distribution of the nutritious nervous juice from the brain to the lower areas.[15]

Mechanical Models

Charleton did not refer to the qualities of individual foods, nor did he indicate which were good sources of the two classes of nutrients that he discussed. But it was obviously more difficult to understand how plant foods could provide the substances needed for growth or "maintenance" than how animal products such as meat could be reconverted to animal (or human) tissue. The next 70 years were dominated by the successes of Newton and others in explaining phenomena in terms of physics, and mechanics in particular. Not unexpectedly, enthusiasm developed for trying to explain the function of living things as well by a *mechanical physiology* entirely free of chemistry.[16]

It had been suggested as early as 1663 that "the human body itself seems to be but an engine,"[17] and Hermann Boerhaave, the Dutch physician and leading medical teacher of his time, began his textbook for medical students with 99 pages devoted to physics and the admonition that students must familiarize themselves with Newton's *Principia.*[18] Andrew Pitcairn, one of the first lecturers at the Edinburgh Medical School, founded in 1695, concluded that the "animal economy" was no more than a hydraulic system; disease resulted from obstruction of the circulation, and animal heat resulted from friction among the particles in the bloodstream tumbling against the

14. Ibid., pp. 156–62.
15. Mayow (1674), pp. 306–9; Davis (1973), pp. 87–8.
16. Brown (1968), pp. 122–235; Hall (1969), vol. 1, pp. 250–63, 367–408.
17. Boyle (1684).
18. Boerhaave (1719), pp. 1–99.

vessel walls and one another. This also had the effect of mechanically abrading (i.e., grinding down) absorbed nutrients to the appropriate size for deposit in the tissues, whenever there were holes waiting to be filled.[19] The holes had arisen in the first place because of wear on particles in the wall, which then fell out. In the rough and tumble of the bloodstream, these were then finally broken down into pieces small enough to pass out through the pores of the skin as insensible perspiration.

British workers confirmed Santorio's observation of weight loss that could be explained at the time only as being due to insensible perspiration, though not in quite such quantity. Keill reported that with an average intake of 74 oz. food and water, 5 oz. were lost as feces, 38 as urine and 31 by perspiration.[20]

The final conversion of absorbed aliment to usable animal material was thought to result from the combination of the mechanical beat of the heart and the pressure of the air: "In the heart, briskly rubbed together they subtilize and rarefy each other, the more volatile parts grinding and breaking in pieces the grosser and less subtilized; also dulling the edges of the sharper parts."[21] People doing hard physical work – whose hearts were beating more strongly and whose breathing was deeper and more rapid than that of more sedentary people – broke down absorbed food particles more quickly. Delicate food was therefore unsuitable for this class of people, on the assumption that it contained smaller particles, which would quickly be broken down too far and perspired before they could be used to fill in gaps in the tissues. This provided an argument for coarse food being natural and preferable for laborers. By contrast, the richer, and physically less active, classes did not have the digestive vigor to utilize such materials, and actually needed more refined and dainty refreshment.[22]

The same line of argument was used to explain why inactive people needed meat and laborers did not:

> There is a similarity and homogeneity between the muscular flesh of tender, sweet animals and that of the human body; the integral particles of their solids and the component globules of their juices are ready formed... to build up the flesh and furnish out the juices of the latter... with less labour or struggle than those of vegetables in general; as a mason will sooner and more strongly build the walls of a house, who has plain rectangular stones at hand, than one who has rough stones only... which must be first figured or prepared for a solid, durable building.[23]

Enthusiasm for the mechanical approach to medicine was on the wane after 1740, for despite the all-embracing claims for its worth, it had failed

19. Pitcairn (1718), pp. 11, 20, 36–7.
20. Keill (1728), p. 332.
21. Crawford (1724), p. 65.
22. Ibid., pp. 174, 333; Arbuthnot (1731), p. 35.
23. Cheyne (1740), p. xiv.

to produce more effective treatments and was subjected to ridicule. John Arbuthnot wrote in *The Memoirs of Scriblerus:*

> It is well known to anatomists that the brain is a congerie of . . . canals of great length variously intorted and wound up together. . . . Simple ideas are produced by the motion of the spirits in one simple canal; when two canals merge they make what we call a proposition, and when two empty into a third they make a syllogism. . . . That some people think so perversely proceeds from the bad configuration of these canals.[24]

A direct attack on the mechanical system came from the French scholar François Quesnay:

> The idea, which many people hold, that digestion consists of mechanical pulverization or grinding is a fiction devoid of any probability. It bears no relation to the character of the digestive organ or of the foods which are digested there. The stomach is a soft and supple pouch which can only be gently agitated. . . . Also, foods are not typically friable, but doughy or cartilaginous, and usually also soaking in drink in the stomach.[25]

Another of the basic assumptions of the system had been that animal heat could be explained by friction among particles circulating in the blood. This was challenged in the *Proceedings of the Royal Society* for 1745 by a writer who said that, just as in the polishing of marble, greasing or watering was used to prevent friction, so would the fluids of the blood prevent heat from being produced by its circulation.[26] In his opinion, heat came from the fermentation of food and from animal tissues coming into contact with air.[27]

Digestion by Fermentation

In fact, the idea that something similar to fermentation occurred during the digestion of food, or its "concoction" as it was called, was not a new one. These were changes that were easily observed outside the body when foods were kept moist and warm and lost most of their characteristic differences.

The Belgian scholar Jean-Baptiste Van Helmont (1577–1644) had argued that the Ancients' explanation of "vital heat" causing digestion was inadequate. Cold-blooded creatures like fish were as efficient as hot-blooded ones at digestion. There must be some chemical processes at work, and these he attributed to specific "ferments." In the case of the stomach an acid ferment was involved, but one with properties not possessed by simple

24. Aitken (1892), pp. 352–3.
25. Quesnay (1747), Vol. 3, p. 14.
26. Mortimer (1745), pp. 473–4.
27. Ibid., 477.

acids such as vinegar or oil of vitriol (sulfuric acid). The direction of fermentation was also different from that observed to occur spontaneously outside the body.[28] Thus meat left in a warm place undergoes putrefaction, giving off a foul odor, but digestion of meat in the stomach follows a different course.

Thomas Willis (1621–75), a leading medical writer of his time and an Oxford professor before becoming a successful London physician, strongly supported the fermentation concept and considered that it operated throughout the body tissues.[29] He referred to the use of old, sour dough as a starter for making a new batch of bread and suggested, by analogy, that old, "perfected chyle" lodged in the folds of the stomach wall might have the same action in speeding the fermentation of food as it arrived in the stomach.[30]

In some ways it made very little difference whether the digestion of food was considered a mechanical principle or one of fermentation. In either case, the particles present were thought of as being jumbled about and rearranged to give products with different properties. However, later writers did not subscribe to Van Helmont's belief that the fermentation in the stomach was of a particular kind; they assumed that the changes in the digestive system were the same as those seen in the breakdown of materials outside the body. This in turn led to some novel ideas about the principles of good nutrition.

Acid–Alkali Balance

The spontaneous fermentation of grains, flours and starchy or sugary foods such as potatoes or grapes resulted in their becoming acidic. Vinegar production was a well-known example of this. Animal products, however, underwent quite different changes and became alkaline. Robert Boyle, an aristocrat and one of the leading members of the Royal Society from its foundation in 1662, was a pioneer in the attempt to dissociate chemistry from alchemy and to establish it on a rational, scientific basis, and he took an interest in the subject. A material, or vapor, was alkaline, according to Boyle, if it turned a paper soaked in syrup of violets from blue to green; the use of litmus paper, going from red to blue with alkali, was a later development. In 1684 he wrote that putrefied blood and strongly heated hartshorn (deer antlers) each gave off a volatile alkali, which, to him, was identical with that of smelling salts (ammonium carbonate). However, he added that society ladies who visited his laboratory told him that, while the

28. Helmont (1662), pp. 115, 208; Pagel (1956), pp. 524–6; Mendelsohn (1964), pp. 41–3.
29. Davis (1973), pp. 82–6.
30. Willis (1684), p. 12.

smell of the salts was pleasant and refreshing, the smell of the others was disgusting.[31]

François de le Boe (1614–72), who latinized his name to Sylvius, was an influential professor in Holland who argued for the chemical nature of the digestive process. He believed that good health depended on acid and alkaline materials in the body being in balance and thus neutralizing each other. An excess of either caused a condition of *acridity*, which irritated the tissues and was the basic cause of most diseases.[32] From this it seemed to follow that, if people were to remain healthy, they needed a balance of the two types of food that went respectively alkaline and acid when decomposed in the body. This seemed to explain the value of such traditional dietary combinations as bread, which was acescent (acid-producing), and meat, which was alkalescent. A diet tipped slightly to the alkalescent side could be balanced by the addition of vinegar. Scurvy was considered to result from an alkaline acridity, and ships' surgeons were provided with sulfuric acid as a corrective when naturally "sharp" (i.e., acidic) fruits like lemons were not available.[33]

It soon became clear to people pursuing the matter that not all plant materials were acescent. Many types of green leafy materials gave off a volatile alkali either when left to go putrid or when distilled over a fire when still fresh. To the surprise of some, even the leaves of the plants valued as antiscorbutics (e.g., watercress and scurvy grass) proved to be alkalescent.[34] A committee of the Royal Academy of Science in France was set up for the systematic study of the chemical characteristics of different plants.[35] One finding was that mushrooms, either distilled or fermented, gave off so much volatile alkali that "if one did not know better, one would think them to be of animal origin."[36]

Herman Boerhaave, who was, as mentioned before, the most influential teacher of medical theory at the beginning of the eighteenth century, did not agree with all of Sylvius's ideas about acids and alkalies in the digestive processes.[37] However, he pointed out that, in view of animals' ability to live entirely on acescent vegetable foods, the predominantly acid chyle that they produced must gradually be changed to animal tissues with their alkalescent qualities. Therefore, the process of *animalization* of plant foods, as he called it, was one of making them more potentially alkaline. He thought

31. Boyle (1684), pp. 116, 121–2.
32. Boas (1956), pp. 14–15.
33. Boerhaave (1715), pp. 313–21; Arbuthnot (1731), pp. 176–7, 181; Carpenter (1986a), pp. 56–7.
34. Homberg (1702), p. 51; Boerhaave (1715), pp. 19–20.
35. Dodart (1731); Holmes (1971), p. 136; Stroup (1990), pp. 89–100.
36. Lemery (1721), pp. 25, 30.
37. Jevons (1962).

that the heat of the body fostered these chemical changes. Again, he argued that laboring peasants with their more vigorous physique were more capable of this than the physically inactive. Bread and vegetables were therefore suitable for peasants, while the rest of society needed inherently alkalescent foods, like meat and eggs.[38]

The Discovery of Wheat Gluten

The next important finding was made by an Italian scholar who had also combined the study of chemistry and medicine. Jacopo Beccari (1682–1766) spent his whole working life in Bologna at the university and academy. The latter was a novel institution supplied with scientific equipment that the university departments of that period did not have.[39]

In the present context Beccari is remembered for a paper published in 1745 (though, in fact, it was an extended minute of a lecture given in 1728).[40] He argued that "our bodies must, presumably, be composed of the same substances which serve as our nourishment,"[41] yet the obvious properties of wheat flour, like those of other plant foods, appeared quite different and almost opposite to the basically gluey nature of muscle, blood and egg white. His new finding was that, in fact, wheat flour did contain some of this "animal glue." It was normally hidden by the larger quantities of other constituents. He had separated it by first sieving coarsely ground wheat so as to remove the branny particles. Then he added a little water to the flour and kneaded a ball of dough (as in bread making, but without yeast), then continued to knead it under water until all the white floury particles in it (i.e., the starch) had dispersed. The residue was a soft, elastic, glutinous mass insoluble in water. When heated strongly, or kept moist and warm for several days so that it began to putrefy, it gave off a "volatile alkali" with a urine-like smell. This was exactly what happened with animal tissues, but it was quite different from the behavior of whole wheat, or of the wheat starch, which went acidic with a wine-like fermentation if left warm and wet.

Beccari believed, therefore, that he had demonstrated that this vegetable food contained a proportion of what could be called "animal substance" and that this provided an explanation for the reputation of bread as being highly nutritious. He was puzzled, however, at being unable to find similar

38. Boerhaave (1719).
39. Heilbron (1991), pp. 62–3.
40. Beach (1961).
41. Beccari (1745). An English translation has been published by Bailey (1941), but translations of this sentence differ greatly. The original Latin is "Nam si corpus tantum spectemus, immortalemque ac divinum animum excipiamus, quid aliud sumus, nisi id ipsum, unde alimur?"