TABLE Report

Primed for Power
a short cultural history of protein

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TABLE

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Introduction

The word 'protein' seems to hold a special power. In dieting culture it represents virtue—and even in broader discussions of weight and obesity it sometimes seems like the golden bullet for managing satiety. In discussions of health and fitness, protein is muscle and strength, fuel for the gym and vital for healthy aging. When we occupy the roles of mother, father or custodian, protein is the carrier of our care, the ensurer of infant growth—even our pets deserve more and better protein.[1] When talking about the future, protein may symbolise hope: 'protein transitions' describe the consequence of greater wealth and success in developing countries, a route to environmental sustainability and greener economies in wealthy ones. But protein is also the bottleneck in the path to a better future, the limiting nutrient in a 'broken' global food system strained by climate crisis.[2] 'Alternative proteins' promise wealth to Silicon Valley investors, a chance for entrepreneurs to feed the world or save the planet. Protein is technology and futurism—it's no accident that Bowie's Major Tom took 'protein pills' and not supplements of some other nutrient.

Can one nutrient really be so central in so many areas of our lives? In her 2013 book *Hidden hunger*, sociologist Aya Kimura describes 'charismatic nutrients': nutrients which are imbued with a special, cultural authority for a period of time, and that take centre-stage in discussions of food security and international development to a

1 Marica Vinassa et al., 'Profiling Italian Cat and Dog Owners' Perceptions of Pet Food Quality Traits', *BMC Veterinary Research* 16, no. 1 (December 2020): 131, https://doi.org/10.1186/s12917-020-02357-9.

2 Danielle E. Medek, Joel Schwartz, and Samuel S. Myers, 'Estimated Effects of Future Atmospheric CO2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region', *Environmental Health Perspectives* 125, no. 8 (16 August 2017): 087002, https://doi.org/10.1289/EHP41.

degree that goes beyond their 'scientific values'.[3] Might this describe protein in current discourse in the Global North? Certainly the simple fact of its recurrence in such different spheres should make us wonder, and in some obvious ways the hype does seem to extend further than the science can support. "[I]f you are worrying about the amount of protein in your diet," writes food journalist Bee Wilson, "then you are almost certainly eating more than enough"[4]: the enthusiasm for protein is focused in high income countries where estimated rates of protein deficiency are in the range of 1-6%.[5] Advertisers trade on the magical quality of the word 'protein' and on consumers' need to make quick judgements—and dieticians despair at chocolate bars rebranded as healthy because of their protein content.

There are some extremely good reasons to focus our discussions of food and sustainability on protein. The food system is responsible for around a third of greenhouse gas emissions[6] and plays an even bigger role in some other environmental costs—deforestation and other land-use change, soil erosion, eutrophication. Within this, certain major sources of protein are very costly foods from an environmental standpoint. Even more importantly, among protein-rich foods we see a much bigger disparity between the largest and smallest environmental impacts than in any other class of foodstuff.[7] This suggests that changing the amount of protein we eat in the Global North, the sources of protein we choose and how we produce it are all powerful levers we could pull in responding to the climate and biodiversity crises.

At the same time, there's no living without protein. Of the 21 amino acids, nine are 'essential' in healthy, adult humans: our bodies cannot produce them from other things, and so to stay alive we must get them directly from what we eat and drink. Contrast this with carbohydrates, which, as far as we can tell, are not in and of themselves essential nutrients.[8] On top of this, meat, milk and other animal-sourced foods—some of the most important sources of protein in many cultures—are dense sources of many other micronutrients, such as the B vitamins and calcium. Livestock are central to the livelihoods of many of the poorest people in the world. Changing our production and consumption of protein is, unavoidably, a fraught business.

Even in light of all of this, we might wonder whether the focus on protein in food systems discourse is proportionate[9]—and in health and nutrition discourse, especially among non-experts in the Global North, it seems clear that it is not. But why? How has the rhetorical power of protein grown larger than the science can support?

One answer is simply that it's the only one of the three macronutrients without an image problem. Fats, demonised since the 1970s as a risk factor for heart disease, accrued associations of gluttony and ill-health (it doesn't help that in many languages the word for 'fat' is the same as or related to a word for 'overweight'). There is an even longer history of warnings against carbohydrates; in the most recent episode in this history, 'carbs'—especially sugars—have played the role of the villain of dieting discourse since the early 2000s.[10] In the popular imagination, only protein remains a straightforwardly 'good' nutrient.

3 Aya Hirata Kimura, Hidden Hunger: *Gender and the Politics of Smarter Foods* (Ithaca: Cornell University Press, 2013), 19–38.

4 Bee Wilson, 'Protein Mania: The Rich World's New Diet Obsession', The Guardian, 4 January 2019, https://www.theguardian.com/news/2019/jan/04/protein-mania-the-rich-worlds-new-diet-obsession.

5 Medek, Schwartz, and Myers, 'Estimated Effects of Future Atmospheric CO2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region'.

6 M. Crippa et al., 'Food Systems Are Responsible for a Third of Global Anthropogenic GHG Emissions', *Nature Food* 2, no. 3 (March 2021): 198–209, https://doi.org/10.1038/s43016-021-00225-9.

7 J. Poore and T. Nemecek, 'Reducing Food's Environmental Impacts through Producers and Consumers', Science 360, no. 6392 (June 2018): 987–92, https://doi.org/10.1126/science.aaq0216.

8 Justin Tondt, William S. Yancy, and Eric C. Westman, 'Application of Nutrient Essentiality Criteria to Dietary Carbohydrates', *Nutrition Research Reviews* 33, no. 2 (December 2020): 260–70, https://doi.org/10.1017/S0954422420000050.

9 iPES-Food, 'The Politics of Protein: Examining Claims about Livestock, Fish, "Alternative Proteins" and Sustainability' (iPES Food, 2022), https://www.ipes-food.org/_img/upload/files/PoliticsOfProtein.pdf.

10 A. F. La Berge, 'How the Ideology of Low Fat Conquered America', *Journal of the History of Medicine and Allied Sciences* 63, no. 2 (30 August 2007): 139–77, https://doi.org/10.1093/jhmas/jrn001; Dariush Mozaffarian, Irwin Rosenberg, and Ricardo Uauy, 'History of Modern Nutrition Science—Implications for Current Research, Dietary Guidelines, and Food Policy', *BMJ*, 13 June 2018, k2392, https://doi.org/10.1136/bmj.k2392.

Still, this explanation is only partial—the power of protein is a much older and more complex phenomenon than this implies, even if we restrict ourselves to the cultures of the world's wealthy countries. Looking at the longer history of protein, we can identify that its prominence has waxed and waned before. If right now countries in the Global North are in the grip of a fashion for protein, it is perhaps the third time that this has happened. And there is a value to understanding that history. Making balanced decisions about the future of our food system that take into account to the enormous complexity of the evidence asks that we understand ourselves, what meaning we ascribe to things and where that meaning comes from. One extremely good way to gain such understanding is through the study of history.

The short essay that accompanies this paper tries to answer the question "Where does the cultural power of protein come from?" directly, looking at the foods associated with protein and the patterns that have repeated in the history of discourse about protein in the Global North. This paper charts that history in more detail. Using stories of individuals and institutitions from two centuries of nutrition science, it will explore some of the history that lies behind the place of protein in present-day culture: why it means what it means, and what happened the previous times that protein was in the spotlight. If these seem to be disproportionately the stories of influential and wealthy white men, that reflects the historical reality of who was allowed into respectable academia. One lesson of this history is that the development of scientific truth is not straightforwardly a matter of 'discovering' but rather of co-creating[11]: the particular people with the resources and platforms to shape our cultural conception of protein inevitably shaped it according to their own biases and interests.

Protein and protein-rich foods

'Proteins' in biochemistry are an enormous class of complex biological molecules[12] with functions ranging from fighting off infections to digesting food. What unites this disparate group is structural: they are all made up of sequences of a smaller group of chemicals called amino acids. Because our digestive systems can break proteins down into their component amino acids and use these to create new proteins, when discussing nutrition we do not always have to distinguish all the different proteins found in food, and instead usually talk just about the 21 amino acids used by animals—and primarily the 11 'essential' amino acids that human bodies cannot synthesise from the others. Phrases like 'protein rich foods' and 'high protein foods' are often used in the food systems literature but not generally given a precise definition.

11 Bruno Latour, *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge, Mass: Harvard University Press, 1999), 145–73.

12 It is estimated that somewhere between 0.62 and 6.13 million different proteins are found just in human beings; Elena A. Ponomarenko et al., 'The Size of the Human Proteome: The Width and Depth', *International Journal of Analytical Chemistry* 2016 (2016): 1–6, https://doi.org/10.1155/2016/7436849.

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1. The primary substance

Scientific claims can leave a cultural imprint which lasts long after expert consensus has moved on.[13] This pattern will prove important in understanding several episodes in the history of protein, not least the story of its 'discovery'.

The word *protein* (more specifically *Protéin*) was first used in a publications by Dutch chemist Gerrit Mulder in 1838.[14] Mulder had been working on the elemental compositions of various organic substances believed to be major constituents of animal tissues (fibrine, gelatine, egg albumen) as well as similar substances found in plants. These all contained nitrogen, carbon, oxygen and hydrogen—but since it was the presence of nitrogen that distinguished them from other plant and animal substances, they were often referred to as the 'nitrogenous substances'. Mulder had discovered that the proportions of these component elements in all these substances were nearly identical; by this measure, the nitrogenous substances differed from each other only in very small quantities of phosphorus and sulphur. He hypothesised, reasonably enough, that they were in fact all *the same compound*: he envisaged a radical[15] produced by plants, consumed by animals and passed up the food chain, being modified only slightly in each body. This hypothetical substance he named *protein*, and claimed it was possible to remove the phosphorus and sulphur from any of the nitrogenous substances and so create pure protein.

This choice of name was significant. Letters from the time show that the idea had come from the far more famous chemist Jöns Jacob Berzelius.[16] Writing to Mulder, Berzelius explained that he had derived the word *protéine* from Greek—but the details are a little confused. Authors in the following decades gave different accounts, mentioning several related Greek words meaning 'good quality, best'[17], 'supremacy, first prize'[18], 'take first prize, hold supremacy, be first'[19] and simply 'first'[20]. It is not entirely clear from Mulder and Berzelius' writings which of these words they had in mind[21] and which particular meaning they intended to invoke—Mulder himself usually referred to the Latin word *primarius* in explanation. The logic could have been that this was "the first nutrient in the food chain", or "the highest quality foodstuff", or "the food of the foremost people" or "the most

13 Geoffrey Cannon, 'Nutrition: The New World Map', *Asia Pacific Journal of Clinical Nutrition* 11 (December 2002): S486, https://doi.org/10.1046/j.1440-6047.11.supp3.4.x.

14 G.J. Mulder, 'Sur la composition de quelques substances animales', in *Des science physiques et naturalles en Néerlande*, by F.A.W. Miquel, G.J. Mulder, and W. Wenkebach (Leyde: P. H. van den Heuvell, 1838), 104–19; Gerardus Johannes Mulder, 'Zusammensetzung von fibrin, albumin, leimzucker, leucin usw.', *Annalen der Pharmacie* 28, no. 1 (1838): 73–82.

15 A 'radical' in the chemistry of the time was a connected series of atoms which could exist as a compound or as a subpart of a larger compound. This has a relatively distant historical relationship with the use of the word 'radical' in modern chemistry to refer to a molecule or atom with an unpaired electron.

16 Hubert Bradford Vickery, 'The Origin of the Word Protein', *Yale Journal of Biology and Medicine* 22, no. 5 (1950): 387–93; Harold Hartley, 'Origin of the Word "Protein"', Nature 168, no. 4267 (August 1951): 244–244, https://doi.org/10.1038/168244a0.

17 Henry George Liddell and Robert Scott, *A Greek-English Lexicon. Revised and Augmented throughout by Sir Henry Stuart Jones with the Assistance of Roderick McKenzie* (Oxford: Clarendon Press, 1940), 'πρώτειος'.

18 Liddell and Scott, *A Greek-English Lexicon. Revised and Augmented throughout by Sir Henry Stuart Jones with the Assistance of Roderick McKenzie*, 'πρωτεῖον'.

19 Liddell and Scott, *A Greek-English Lexicon. Revised and Augmented throughout by Sir Henry Stuart Jones with the Assistance of Roderick McKenzie*, 'πρωτεύω'. It is clear that this is not the word intended by Mulder or Berzelius, but many other scholars seem to have believed it to be; e.g. George E. Day, *Chemistry and Its Relation to Physiology and Medicine* (London: Hippolyte Baillière, 1860), 101; Frederic R. Rees, *Scientific Teetotalism. Appendices to The Illustrated History of Alcohol; Exhibiting a View of the Accordance of Teetotalism with Recent Discoveries in Organic Chemistry, and Explaining the Modus Operandi of Alcohol; Firstly, on the Function of Respiration, and, Secondly, in the Formation of Fat* (London: W. Brittain, 1843), ii; Justus Liebig, *Animal Chemistry, Or Organic Chemistry in Its Applications to Physiology and Pathology*, ed. William Gregory (London: Taylor and Walton, 1842), 146; Robert Bentley Todd and William Bowman, *The Physiological Anatomy and Physiology of Man* (Philadelphia: Lea and Blanchard, 1850), 56; Benjamin Silliman, *First Principles of Chemistry For the Use of Colleges and Schools* (Philadelphia: H.C. Peck & T. Bliss, 1850), 454.

20 Liddell and Scott, *A Greek-English Lexicon. Revised and Augmented throughout by Sir Henry Stuart Jones with the Assistance of Roderick McKenzie*, 'πρῶτος'; similarly clearly not the word intended by Mulder and Berzelius, this more basic form was nevertheless probably evoked for many people by the word *protéine*, as well as occasionally being interpreted as the etymon—e.g. J. M. F. Browne, 'The Protein Compounds', *American Eclectic Medical Review* IV (1869): 444.

21 Berzelius seems to have meant πρώτειος, but wrote πρωτειος without an accent (which was not uncommon); Mulder wrote πρωτεῖος—either meaning the same but getting the accent wrong, or really intending πρωτεῖον and getting the ending wrong.

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important component of food". Instead of a clear explanatory story, the etymology offered a cloud of connotative links between the new word *protein* and notions of firstness, quality, primacy and supremacy.[22]

This idea of a single substance which underlay the food chain and was the building block of all animal tissues came to be called 'protein theory'. It was, however, short lived. The theory was briefly taken up by celebrity scientist Justus von Liebig, who claimed in his response to Mulder to have reproduced his results and created pure protein in the lab.[23] Liebig and his graduate students focused intensely on protein theory from 1838 onwards so that it could be included and elaborated upon in Liebig's *Animal Chemistry* (1842).[24] Where Mulder's papers had presented a hypothesis, Liebig's book offered settled scientific facts: 'proteine' was a single compound, synthesised in plants, consumed by herbivores and passed up the food chain; it was carried throughout the body by blood, where all other animal tissues (generally compounds of proteine with small quantities of phosphates, other salts, sulphur and phosphorus) were produced.

For a short period, protein theory was popular—but Liebig received a mixed response to *Animal Chemistry*, and became embroiled in a bitter conflict with Berzelius over criticisms of it.[25] Liebig's initial optimism about removing the 'impurities' from albumen, fibrine and caseine and so creating 'pure protein'—the experimental proof that the theory needed—faltered as his students failed to make progress.[26] He went on to claim that Mulder had misled him and by 1847 was attacking both the theory and its originator in no uncertain terms, saying that "Mulder's theory of proteine is fallacious", that "proteine does not exist", and that "so-called proteine theory" should not even be regarded as a scientific theory.[27] This resulted in an angry exchange of public recriminations with Mulder of a kind that punctuated the whole of Liebig's scientific career.

For the following three decades, protein theory remained contentious and most writers in English returned to using terms like 'albuminoids', 'albuminous substances' or 'nitrogenous substances' as a shorthand for albumin, fibrin, casein and so on.[28][29] The word *protein* and its variants (*proteine*, *protein-bodies*, *proteinous substances*, *proteid*; German *Proteine*, French *protéine*) continued to crop up in texts on organic chemistry, generally when making reference to protein theory,[30] alongside occasional use as a synonym for 'nitrogenous substances' or 'albuminous substances'.[31] We also find instances of *protein* being used as a term for the 'nutritive' (nitrogen-containing) component of crops.[32] Since *protein* remained a relatively unusual, technical term, many of these authors felt it necessary to introduce it in some way—typically by making reference to Mulder and offering some version of the etymological story. In this way, even though Mulder's theory never gained any lasting acceptance, a set of impressionistic associations between the word *protein* and firstness, quality and supremacy were firmly established.

22 For example, Wilson (1854) explains that protein 'is so called because, itself a primary substance, it originates so many dissimilar substances'; Erasmus Wilson, *A System of Human Anatomy* (Philadelphia: Blanchard and Lea, 1854), 35.

23 Charles Tanford and Jacqueline Reynolds, *Nature's Robots: A History of Proteins*, 1. issued in paperback (New York, NY Oxford: Oxford Univ. Press, 2003).

24 Liebig, *Animal Chemistry, Or Organic Chemistry in Its Applications to Physiology and Pathology*; W. H. Brock, Justus von Liebig: *The Chemical Gatekeeper* (Cambridge ; New York: Cambridge University Press, 1997), 183–85.

25 Brock, *Justus von Liebig*, 183–86, 193–95.

26 Brock, 195–96.

27 Justus Liebig, *Researches on the Chemistry of Food*, ed. William Gregory (London: Taylor and Walton, 1847), 15, 18, 23, 27.

28 Kenneth J. Carpenter, *Protein and Energy: A Study of Changing Ideas in Nutrition* (Cambridge [England] ; New York: Cambridge University Press, 1994), 56.

29 Similar catch-alls were used in other languages, such as German *Eiweiß* and Dutch *eiwit* (literally 'egg-white') and French *albumine*.

30 e.g. as late as Browne 1869; Browne, 'The Protein Compounds', 444.

31 e.g. in Day 1860, who uses the term 'Protein-bodies' as a catch-all; Day, *Chemistry and Its Relation to Physiology and Medicine*, 101.

32 A clear example is found in Browne 1847. Browne compares the proportions of 'proteine', 'fatty matter', starch and water in wheat, oats, barley, potatoes, rice and maize, ranking their 'nutritive values' by protein content: wheat, oats, barley > maize > rice > potatoes. J. Browne, 'A Memoir on Maize or Indian Corn', in *The Hasty-Pudding; A Poem, in Three Cantos. Written at Chamrery, in Savoy, January, 1793, by Joel Barlow, Minister Plenipotentiary to France. With A Memoir on Maize or Indian Corn* (New York: W.H. Graham, 1847), 38.

2. Meat makes meat: the first protein fashion

Liebig and Mulder's work on protein and the chemistry of nutrition was not taking place in a vacuum. In France in the 1830s and 40s, administrators and scholars like Jean-Baptiste Boussingault and Jean-Baptiste Dumas worked on the science of nutrition not solely out of scientific interest but motivated by social, economic and political concerns.[33] Boussingault and Dumas framed nutrition in terms of the slow combustion of food carbon and the expenditure of bodily tissue through activity. Some scholars were motivated by the problem of feeding an expanding labour force: in a situation of scarcity, what must the worker eat (and, consequently, be paid) in order that labour be able to reproduce itself?[34] Here, the question was both that of identifying how much tissue was 'used up' through work (and so needed to be replaced with food), and what resources were needed to raise children to replace the labourer himself—although more emphasis was put on the first of these two. This frame was of interest to industrialists wanting to identify the floor to which wages could be lowered. For social reformers, on the other hand, nutritional science promised both explanations and solutions—what might the relationship be between problems of poverty, disease and ill-health, and inadequate diets? Did poverty cause poor dietary health, or did poor dietary choices cause enfeeblement and therefore poverty? Social surveys mapping out incomes and dietary habits offered the tools to probe these questions.[35] For administrators, an interest in nutrition arose from the challenges of managing institutions, particularly prisons and schools, whether with an eye to the humane treatment of inmates or simply to efficiency. In many of these cases, a growing idea of state responsibility for public welfare helped to make nutrition and agriculture areas of scientific interest.

Another important context for the precipitous rise and fall of protein theory was ongoing work on fertiliser and nitrogen in agriculture. There are striking parallels with the work on human nutrition: here too was a search for a singular, crucial nutrient; here too nitrogen compounds played a special role in the debate; some of the same scholars (Liebig, Boussingault, Dumas) were important figures in both fields.

Since the mid-18th century, understanding of plant nutrition had been dominated by the retrospectively-named 'humus theory'. In this theory, all nutrients came from the soil: plants took in water and humus (decayed plant and animal matter) through their roots. This supplied carbon, oxygen, nitrogen and hydrogen, which could then be transformed into the full range of substances found in plant tissues by means of 'vital force' (German *Lebenskraft*).[36] However, experimental work around the turn of the century (particularly an 1804 book by Nicolas-Théodore de Saussure[37]) had suggested that at least carbon dioxide was instead absorbed from the atmosphere.[38]

Two important contributions towards the end of this period were German agronomist Albrecht Thaer's 1809 'Grundsätze der rationellen Landwirthschaft' (translated into English as 'The Principles of Agriculture') and a hugely popular 1813 lecture series by Cornish chemist Humphry Davy. Both were deeply practical works, exploring organic chemistry with a focus on the advice that could be derived for farmers. Both put forward versions of humus theory that allowed that some carbon might be acquired by the plant from the air, but which focused nevertheless on maintaining healthy soil as the primary source of plant nutrition. Davy dedicated a lecture to the efficacy and mode of action of many different organic substances as fertilisers, and the importance of water-solubility in making these substances available to roots; Thaer (whose methods have been recognised as

33 Dana Simmons, *Vital Minimum: Need, Science, and Politics in Modern France* (Chicago ; London: University of Chicago Press, 2015).

34 Simmons, 31.

35 Simmons, 55–78.

36 This was the (to the modern sensibility quasi-magical) idea that living bodies could act on the world with a special power, distinct from the physical and chemical forces that explained actions of and on objects.

37 Nicolas-Théodore de Saussure, *Recherches chimiques sur la Végétation* (Paris: chez la Ve. Nyon, 1804), https://archive.org/details/rechercheschimi02sausgoog.

38 R.R. van der Ploeg, W. Böhm, and M.B. Kirkham, 'On the Origin of the Theory of Mineral Nutrition of Plants and the Law of the Minimum', *Soil Science Society of America Journal* 63, no. 5 (September 1999): 1055–62, https://doi.org/10.2136/sssaj1999.6351055x.

a precursor of organic farming) recommended rotating cash crops with forage crops, fallowing, and fertilising the soil with manure to maintain the right nutrient balance.[39]

In the 1820s, a student of Thaer, Carl Sprengel, demonstrated that soil contained many mineral salts which could be taken up by plant roots—obviating the need for vital force to create phosphorus, sulphur, and so on by transmutation. He proposed that plant growth was limited by whichever of these nutrients was least available in the soil—the 'Law of the Minimum'. Sprengel received little recognition for this work, but his observations were taken up by Liebig in an 1840 book which established 'mineral theory'. This broke with humus theory by asserting that plants got all of their carbon and oxygen from the atmosphere, and only the mineral nutrients from the soil. An important practical implication was that fertilisers need not be organic substances: instead, it should be possible to identify the limiting missing minerals in a given soil and synthesise an artificial fertiliser to supply them.[40]

In the early 1840s international trade had already opened up new agricultural technologies. Indigenous peoples of the Andes had traditionally mined deposits of seabird droppings—guano—for use as fertiliser. This had been known in the west for some time—indeed, Davy's lectures had mentioned the efficacy of guano in 1813 [41] —and by the 1830s and 40s huge quantities of guano were being imported from Peru to Great Britain and on from there. Liebig saw an entrepreneurial opportunity in designing a targeted fertiliser that could be produced cheaply and locally. In the book which laid out mineral theory, he had explained the power of guano as a fertiliser on the basis that it supplied nitrogen needed for plant growth in the form of ammonia.[42] However, shortly after publication he changed his mind and argued that enough nitrogen reached the soil through precipitation of atmospheric ammonia to supply the plant's needs.[43] So confident was he in this new theoretical work that he saw no need to perform field tests when he designed a mineral fertiliser for commercial production. This product, which was composed primarily of water-insoluble calcium phosphate[44] and contained no ammonia, was launched in 1845 and proved to be completely ineffective; [45] Liebig would later acknowledge that he had hugely underestimated the importance of nitrogen—and also of practical experimentation.[46] English agriculturalist John Lawes' similar chemical fertiliser—informed by Liebig's mineral theory but actually tested in the field before its commercial release in 1843—was far more successful.[47]

There are both direct connections and important parallels between this work on plant nutrition and the debates around human nutrition. As journalist and nutritional scholar Geoffrey Cannon has pointed out, both projects involved the use of organic chemistry to search for a substance that would promote growth: a plant fertiliser and a human 'fertiliser'.[48] In both cases, nitrogen compounds played a major role in the debate and were sometimes

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39 Brock, *Justus von Liebig*, 145–46; Humphry Davy, *Elements of Agricultural Chemistry, in a Course of Lectures of the Board of Agriculture* (London: Longman, Hurst, Rees, Orme, and Brown, 1813); Raphaël J. Manlay, Christian Feller, and M.J. Swift, 'Historical Evolution of Soil Organic Matter Concepts and Their Relationships with the Fertility and Sustainability of Cropping Systems', *Agriculture, Ecosystems & Environment* 119, no. 3–4 (March 2007): 217–33, https://doi.org/10.1016/j.agee.2006.07.011; Christian Feller et al., 'Soil Fertility Concepts over the Past Two Centuries: The Importance Attributed to Soil Organic Matter in Developed and Developing Countries', *Archives of Agronomy and Soil Science* 58, no. sup1 (October 2012): S3–21, https://doi.org/10.1080/03650340.2012.693598.

40 van der Ploeg, Böhm, and Kirkham, 'On the Origin of the Theory of Mineral Nutrition of Plants and the Law of the Minimum'.

41 Davy, *Elements of Agricultural Chemistry, in a Course of Lectures of the Board of Agriculture*, 274–76.

42 Justus Liebig, *Organic Chemistry in Its Applications to Agriculture and Physiology*, ed. Lyon Playfair (London: Taylor and Walton, 1840), 81–82.

43 Eville Gorham, 'Biogeochemistry: Its Origins and Development', *Biogeochemistry* 13, no. 3 (1991), https://doi.org/10.1007/BF00002942.

44 Anthony S. Travis, 'Agricultural Chemistry', in *Nitrogen Capture*, by Anthony S. Travis (Cham: Springer International Publishing, 2018), 9–18, https://doi.org/10.1007/978-3-319-68963-0_2.

45 William H. Brock, 'Justus von Liebig. Gatekeeper of Chemistry', Chemical Society Reviews 24, no. 6 (1995): 383, https://doi.org/10.1039/cs9952400383.

46 Justus von Liebig, 'Some Points on Agricultural Chemistry', *Journal of the Royal Agricultural Society of England* XVII, no. 1 (1856); Carpenter, *Protein and Energy*, 48; Brock, *Justus von Liebig*, 120–29.

47 Brock, *Justus von Liebig*, 121–22; A. J. Macdonald, ed., *Rothamstead Long-Term Experiments: Guide to the Classical and Other Long-Term Experiments, Datasets and Sample Archive* (Harpenden, Herts: Rothamstead Research, 2018), http://www.rothamsted.ac.uk/sites/default/files/Web_LTE%20Guidebook_2019%20Final2.pdf.

48 Cannon, 'Nutrition', S486.

seen as *the* singular nutrient—nitrogen in the form of ammonia as a limiting nutrient in fertiliser, and the nitrogenous substances as the key component of food needed for growth and health in humans. And, as we shall see, both fields were shaped by entrepreneurial as well as scientific goals.

Although he quickly abandoned protein theory per se, Liebig's *Animal Chemistry* and subsequent *Researches on the Chemistry of Food* established a theory of nutrition and energy that he, his students and his students' students would continue to develop for much of the rest of the 19th century—a theory which owed something to the work of Boussingault, Dumas and their predecessor Antoine Lavoisier, and much to Mulder's protein theory. In it, foodstuffs were divided into two types with different functions: nitrogenous foods, used to build tissue which was then expended in muscle movement and had to be replaced; and all other foods that merely fuelled 'respiration'—the combustion of carbon to maintain body heat.[49] The latter is roughly the Dumas-Boussingault conception of nutrition, the former is Mulder's protein.

Crucially, where Dumas and Boussingault thought that animal bodies could not transform one nutritional substance into another (for example, sugar↔fat), Liebig thought this constraint applied only to nitrogenous substances.[50] This gave the nitrogenous substances a special dietary importance: they were the only parts of food that were truly necessary, since they could not be created by the body from other things. A body fed only nitrogenous substances would use some for tissue formation (and so muscle movement) and transform the remainder for respiration to keep warm; by contrast, if no nitrogenous substances were supplied, tissue would gradually be used up and the body would waste away.

In this framework, Liebig extolled the importance of meat.[51] Raw meat, he reasoned, was the only foodstuff that must contain all the substances required to recreate flesh. This had implications for cookery: "if flesh, employed as food, is again to become flesh in the body," he wrote, it was of crucial importance not to remove or totally transform any components of it.[52] Water in which meat had been boiled should be retained and consumed, since many important nitrogenous substances were water-soluble (his English editor helpfully pointed out in a footnote that this described the existing process of making stock[53]).

Liebig's celebrity over his long career helped to ensure that his ideas about nutrition exerted significant influence on cookery books and housekeeping books: his name alone was felt to be a selling point when advertising ostensibly healthful foods.[54] He founded *Liebig's Extract of Meat Company* (or *Lemco*, which created the brands Fray Bentos and OXO) to process the meat that could now be imported cost-efficiently (though controversially[55]) from Uruguay, Australia and elsewhere into a concentrated liquid which purportedly retained all the important dietary components of meat. This extract was later criticised for containing little of nutritional value, prompting Liebig to reframe it as a stimulant and shift to selling tinned corned beef (still under the Fray Bentos brand), itself an invention that was transforming the global food system. Via Lemco's success and his own celebrity, Liebig's influence on the meat industry and advertising, on culinary culture, and on societal beliefs about meat long outlasted his scientific theories themselves.[56]

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49 Liebig, *Animal Chemistry, Or Organic Chemistry in Its Applications to Physiology and Pathology*, 96; Kenneth J. Carpenter, 'The History of Enthusiasm for Protein', *The Journal of Nutrition* 116, no. 7 (1 July 1986): 1365, https://doi.org/10.1093/jn/116.7.1364.

50 Brock, *Justus von Liebig*, 187; Simmons, *Vital Minimum*, 16.

51 Corinna Treitel, 'Max Rubner and the Biopolitics of Rational Nutrition', *Central European History* 41, no. 1 (March 2008): 9, https://doi.org/10.1017/S0008938908000022.

52 Liebig, *Researches on the Chemistry of Food*, 122–34.

53 Liebig, 123–24.

54 Rima Apple, 'Science Gendered: Nutrition in the United States, 1840–1940', *Kappa Omicron Nu FORUM 10* (1997): 15.

55 The unpalatability of early attempts at freezing and tinning meat led to public concerns that meat from colonial sources was poor quality or a risk to health--although this did not stop entrepreneurs like Liebig in the long run. Rebecca J. H. Woods, 'From Colonial Animal to Imperial Edible', *Comparative Studies of South Asia, Africa and the Middle East* 35, no. 1 (1 May 2015): 127, https://doi.org/10.1215/1089201X-2876140.

56 Cannon, 'Nutrition', S486.

From about 1870, the use of the word *protein* as catch-all for nitrogenous substances began to rise in frequency in texts on human and animal nutrition (cf. Figure 1). No-one was arguing as Mulder had that there was a single chemical from which all animal tissue was formed and the exchange of which was the sole basis of the food chain. Instead, it seems that the word protein had lost its association with Mulder's debunked theory of *chemistry* while still retaining the connotation of being the 'primary substance of nutrition'.[57] By this point, Adolf Fick and others had experimentally demonstrated that more energy was expended in muscular work than could be accounted for by protein nutrition alone.[58] This should have ruled out Liebig's theory of nutrition—if protein intake couldn't account for muscular work, then movement could not be driven by 'burning' muscle tissue and protein could not have the unique dietary function Liebig had assigned it. What is more, an important prediction of the theory had been that physical work should result in increased nitrogen content in urine as the proteinous substance of flesh was expended—and this prediction was repeatedly disproven in both dogs and humans. Instead, such exertion was found to be associated with increased carbon in urine. Nevertheless Liebig and his students such as Carl Voit continued to emphasise the idea that muscular work relied solely on protein and could not be powered by carbohydrate or fat, even when serious intellectual gymnastics were required to ignore the mounting evidence to the contrary.[59]

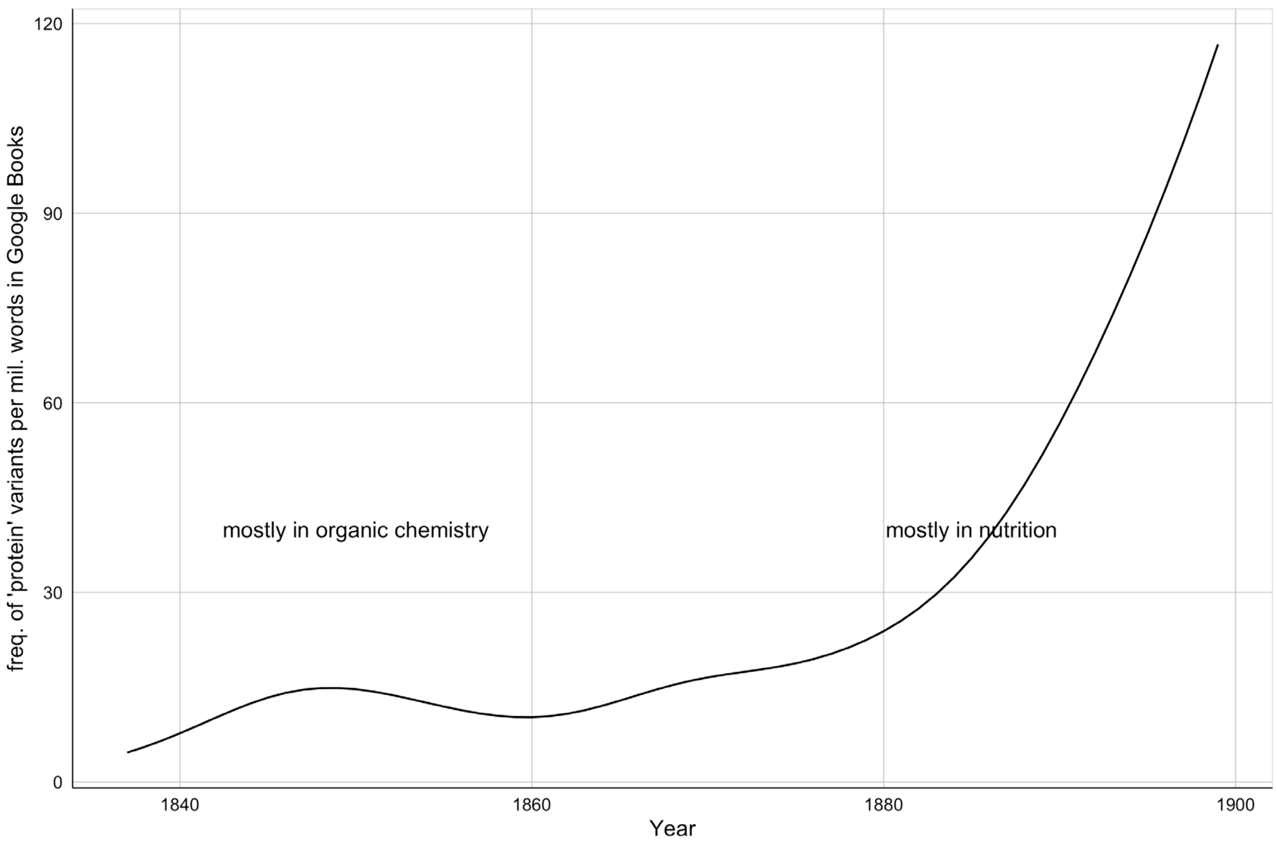

Figure 1. Use of protein and related forms in Google Books by date

57 an example is 'if protein be supplied there can be no absolute need for any other but the mineral food-stuffs'; Thomas Henry Huxley and W. M. Jay Youmans, *The Elements of Physiology and Hygiene; A Text-Book for Educational Institutions* (New York: D. Appleton and Company, 1868), 136.

58 Kenneth J. Carpenter, Alfred E. Harper, and Robert E. Olson, 'Experiments That Changed Nutritional Thinking', *The Journal of Nutrition* 127, no. 5 (1 May 1997): 1017S-1053S, https://doi.org/10.1093/jn/127.5.1017S.

59 Carpenter, 'The History of Enthusiasm for Protein', 1986; Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (Berkeley: University of California Press, 1992), 125–26; Carpenter, *Protein and Energy*, 64–76.

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The German school of nutrition was not monolithic and nutritional science did not stay still. Voit, in a bitter break with Liebig, argued that starch and fat *could* serve nutrition and that Liebig's "erroneous view" that these nutrients contributed only to 'respiration' (the maintenance of body heat) had mistakenly brought protein to be regarded as a uniquely important nutrient.[60] Yet Voit continued to argue for a high bodily requirement for protein that increased with muscular work. Voit's student Max Rubner, taking advantage of the developing science of thermodynamics as well as improved calorimeter designs, partially broke with Voit and Liebig to frame bodily requirements not in terms of carbon and nitrogen but in terms of energy. Nutritional needs could now be completely expressed in terms of calories and protein,[61] and the first estimates of daily dietary requirements in this form appeared in Germany, the Netherlands, the UK and the US.

Rubner also broke with Liebig and Voit on the specifics of dietary need for protein. Estimates of daily requirements for protein had been a part of the discourse on nutrition since Mulder estimated in 1847 that a typical labourer needed to consume 100g of protein per day[62] (to compare this to other recommendations from the time and to modern estimates, see Figure 4). Numbers such as this were derived in two ways. Firstly simply by observing the actual diets of particular segments of the population and calculating how much protein they were consuming.[63] The second, more exacting method was to place subjects on a controlled diet and measure the amount of nitrogen in their excreta. This worked on the assumption that the diet should contain at least enough protein to compensate for the amount of nitrogen lost each day[64]—'nitrogen balance' methods descended from these early experiments are still central to the calculation of protein requirements today.

There was a risk of circularity with both of these methods. Much of the impetus for this work came from conflict and concern around industrial labour in cities, and so there were strong biases towards certain sorts of bodies and livelihoods. The greatest interest (coming from industrialists, social reformers, unionists and Marxists alike—though for different reasons) was in the needs of men doing demanding physical labour. Scholars offered gradated estimates for different types of labourer, and more rarely also for women; however, these estimates tended to have less prominence than the headline figure for highly active men. For example, in 1876, Voit proposed that a man undertaking moderate work required 118g of protein per day and a man undertaking hard work 145g of protein per day.[65] Although Voit emphasised that he had a particular population in mind and that other demographics would have lower requirements, among the researchers who cited him the figure of 118g/day became the gold standard for a good diet—anything less than this was *Armenkost*, a poverty diet.[66] Since it would be hard to achieve such a high protein intake without eating a lot of meat, by the 1880s it was generally accepted among German scientists that meat was a key element of a 'rational diet'.[67]

The influence of these ideas went far beyond the German-speaking world. It was common in the late 19th century for US scholars wanting to gain expertise in nutrition or chemistry to train in German laboratories; one such scholar was Wilbur Atwater, the first head of the USDA's Office of Experiment Stations, among other

60 'Die verhängnissvolle Consequenz dieser falschen Auffassung war, dass man damals und noch längere Zeit darnach dem Eiweiss vor Allem die Aufmerksamkeit zuwandte und es als den hauptsächlichsten und wichtigsten Nahrungsstoff, ja als den einzigen betrachtete, da es allein den Verlust durch den Stoffwechsel wieder ersetzen sollte und man unter Ernähren nur den Wiederaufbau des durch die Arbeit zerstörten Gewebes verstand.'; Carl von Voit, *Handbuch der Physiologie des Gesammt-Stoffwechsels und der Fortpflanzung*, ed. L. Hermann, vol. Erster theil. Physiologie des allgemeinen Stoffwechsels und der Ernährung (Leipzig: F. C. W. Vogel, 1881), 339.

61 Carpenter, Protein and Energy, 90–94; Treitel, 'Max Rubner and the Biopolitics of Rational Nutrition'; Simmons, *Vital Minimum*, 94.

62 A. E. Harper, 'Origin of Recommended Dietary Allowances—an Historic Overview', *The American Journal of Clinical Nutrition* 41, no. 1 (1985): 140–48, https://doi.org/10.1093/ajcn/41.1.140.

63 Harper, 141.

64 W. B. Halliburton, *A Text-Book of Chemical Physiology and Pathology* (London: Longmans, Green, and Co., 1891), 604–5, 815–16.

65 W. O. Atwater, 'Principles of Nutrition and Nutritive Value of Food', *U.S. Department of Agriculture. Farmers' Bulletin* 142 (1906): 35; Harper, 'Origin of Recommended Dietary Allowances—an Historic Overview', 141; Carpenter, *Protein and Energy*, 89; Treitel, 'Max Rubner and the Biopolitics of Rational Nutrition', 9–13.

66 Treitel, 'Max Rubner and the Biopolitics of Rational Nutrition', 13.

67 Treitel, 9.

accolades.[68] [69] Atwater studied under Voit and built on his beliefs—including concerning the unique importance of dietary protein—and on his methods—including the estimation of dietary needs through observational studies. One study offers us a particularly clear picture of the circularity of such work: Atwater investigated the diets of undergraduate boat crews. His interest in this group was based on the logic that they undertook demanding physical work while facing little financial constraint on their diets, and so could be expected to gravitate to the best diet to keep themselves fit. He found that they had very high protein intakes (155g/day) and saw this as confirmation that protein was required for high muscular activity, just as Voit, Liebig, and others had argued. In retrospect, it has been pointed out that these athletes sat at a special table and were encouraged to eat extra meat by their coaches—who believed (in no small part because of the work of a generation of German nutritionists,[70] cf. Figure 2) that meat-heavy diets were necessary to build strength.[71] [72] A few years later Atwater was to publish the USDA's first dietary recommendations, suggesting an intake of 125g protein per day[73] (more than double the USDA's recommendation today[74]).

The problem of poor nutrition among the urban poor was not only of interest to those engaged with industry and labour, but also to militaries—and thus there was also a military impetus behind the project of identifying protein requirements. During the Boer War of 1899-1902 the British military had struggled to find sufficiently tall and healthy recruits: 40-60% of would-be soldiers failed to meet the statutory height requirement (compared with around 10% in 1845[75]) and this was suspected to be the result of poor nutrition in situations of urban poverty.[76] A committee was set up to investigate, and the nutritional scientists they interviewed were confidently able to pinpoint the root of the problem: too little protein, especially meat and milk (although excessive drinking of overly-stewed tea was also considered a major worry[77]). At the same time, it was feared that problems of public health might be a symptom of the "deterioration of the British race" instead of the result of poverty.[78]

68 Carpenter, *Protein and Energy*, 100.

69 Atwater's name is still familiar to students of nutrition in the context of 'Atwater factors', the system used to estimate the energy content of food.

70 Mikkel Hindhede, *Die Neue Ernährungslehre* (Dresden: Emil Pahl, 1922), 5.

71 W. O. Atwater and Chas. D. Woods, 'Comments on the Dietary Studies at Purdue University', *U.S. Department of Agriculture. Office of Experiment Stations Bulletin* 32 (1896): 23–28; Carpenter, 'The History of Enthusiasm for Protein', 1366; Carpenter, Protein and Energy, 106–7.

72 From a modern perspective, we do indeed expect the wealthiest groups to eat most healthily, so this might strike readers as a reasonable methodological assumption. But the point is that this is inextricably intertwined with the effects of education. Whatever the best recommendations of nutritional science in a given period, we can expect to see those recommendations followed most by the most educated—who are, not incidentally, generally the most wealthy. As a result, differences in dietary habits between social classes may tell us something about economics (the constraints of poverty), culture and access to education; if they also tell us something about instinctive responses to biological needs, that would be very difficult to unravel from these other effects.

73 Atwater, 'Principles of Nutrition and Nutritive Value of Food'.

74 U.S. Department of Agriculture and U.S. Department of Health and Human Services, *Dietary Guidelines for Americans 2020-2025*, 9th Edition (USDA, 2020), 133–34, https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf; note that these are based on reference weights for adult women and men of 57kg and 70kg respectively. By contrast, the US population mean weights observed in 2015-2016 were 77.4kg for adult women and 89.8kg for adult men. Cheryl D. Fryar et al., 'Mean Body Weight, Height, Waist Circumference, and Body Mass Index Among Adults: United States, 1999–2000 Through 2015–2016', National Health Statistics Reports (Hyattsville, MD: U.S. Department of Health and Human Services, 20 December 2018), https://www.cdc.gov/nchs/data/nhsr/nhsr122-508.pdf.

75 Bentley B. Gilbert, 'Health and Politics: The British Physical Deterioration Report of 1904', *Bulletin of the History of Medicine* 39, no. 2 (1965): 143.

76 *Inter-departmental Committee on Physical Deterioration, Report* of the Inter-Departmental Committee on Physical Deterioration, vol. 1 (London: Wyman & Sons, Limited, 1904), 2, 97.

77 Inter-departmental Committee on Physical Deterioration, 1:40–41, 57.

78 The distinction between a weakening of British masculinity caused by an unhealthy urban environment and a heritable 'racial' deterioration was made by some but more often left vague. The committee itself emphasised that they did not believe they had good enough data to draw conclusions about the 'British race' as a whole and so had avoided this phrase. Gilbert, 'Health and Politics: The British Physical Deterioration Report of 1904', 143, passim.; Inter-departmental Committee on Physical Deterioration, *Report of the Inter-Departmental Committee on Physical Deterioration*, 1:102.

The two explanations were intimately connected, since meat-eating in particular was increasingly understood as a site of racial difference and imperial superiority. Meat was believed to be necessary for bodily strength and was at least connotatively linked with desirable psychological traits like bravery and rationality; when it was found that certain populations (particularly in the US, Australia and Germany) had particularly high intakes of meat and that many Asian and African populations particularly low, this offered 19th century thinkers one possible explanation of imperial power and domination as a consequence of natural law ("the effeminate rice-eaters of India and China have again and again yielded to the superior moral courage of an infinitely smaller number of meat-eating Englishmen"[79]). In India, distinctions were made between colonial subjects according to whether their traditional diets promoted 'courage' and 'strength'. Rice in particular was condemned for its low protein content and wheat and lentils identified as preferable—but vegetarian diets of beans and grains were still fundamentally poverty diets compared with meat and milk.[80] The 'ability' to go without eating meat became a racialised symbol that could be weaponised in conflicts over labour and Asian immigration in the US ("you cannot work a man who must have beef and bread alongside of a man who can live on rice"[81]).[82] Institutions in the colonies offered European scientists opportunities to undertake nutritional experiments on populations "limited neither by unwillingness nor small numbers"[83] [84] which identified increased protein (meat, dairy, and possibly wheat) consumption as a means of improving the yield of colonial labour:[85] thus the development of nutritional science was both informed and facilitated by racist-colonial beliefs. That said, it is hard to untangle racial from nationalist motivations here, as meat-eating also played a role in competition between *western* nations: the USDA saw evidence of US national superiority not just in the "starvation diets" of India and China but also in the fact that US protein recommendations were higher than those issued by European scientists.[86]

Ideas about protein increasingly filtered out of the domains of science and governance and into popular thought. This could take place more or less directly, through popular summaries of research[87] and through public health messaging.[88] But commercial advertising also played a major role. Nutritional scientists like Liebig had profited from lending their names to ostensibly healthy foods, but by the turn of the century the public was sufficiently familiar with ideas about protein that claims about protein content could be used to sell food directly (cf. Figure 2). This can be seen in the light of 'nutritionism', the name popularised by academic Gyorgy Scrinis and food writer Michael

79 J. Leonard Corning, *Brain Exhaustion, With Some Preliminary Considerations on Cerebral Dynamics* (D. Appleton and Company, 1884), 196–97.

80 David Arnold, 'The Good, the Bad and the Toxic: Moral Foods in British India', in *Moral Foods: The Construction of Nutrition and Health in Modern Asia, ed. Qizi Liang and Melissa L. Caldwell, Food in Asia* and the Pacific (Honolulu: University of Hawai'i Press, 2019), 119–22.

81 Samuel Gompers and Herman Guttstadt, *Meat vs. Rice; American Manhood against Asiatic Coolieism, Which Shall Survive?* (San Francisco: Published by American Federation of Labor and Printed as Senate Document 137, 1902), 22, https://hdl.handle.net/2027/uc1.32106007093054.

82 Rosanne Currarino, '"Meat vs. Rice": The Ideal of Manly Labor and Anti-Chinese Hysteria in Nineteenth-Century America', *Men and Masculinities* 9, no. 4 (2007): 476–90, https://doi.org/10.1177/1097184X05284993; Vasile Stănescu, '"White Power Milk": Milk, Dietary Racism, and the "Alt-Right"', *Animal Studies Journal* 7, no. 2 (2018): 102–28; Iselin Gambert and Tobias Linné, 'From Rice Eaters to Soy Boys: Race, Gender, and Tropes of "Plant Food Masculinity"', *Animal Studies Journal* 7, no. 2 (2018): 129–79.

83 "limités ni par leur mauvaise volonté ni par leur faiblesse numérique"

84 Jules Amar, *Le Rendement de la Machine humaine* (Paris: Librairie J.-B. Baillière et Fils, 1910), 4, https://wellcomecollection.org/works/kby3fpqt.

85 Amar, Le Rendement de la Machine humaine; Rabinbach, *The Human Motor*, 186; Arnold, 'The Good, the Bad and the Toxic: Moral Foods in British India'.

86 Atwater, 'Principles of Nutrition and Nutritive Value of Food', 36.

87 For example, a summary of Atwater's 1894 article on nutrients appeared in a variety of local newspapers in the US in 1895; among other conclusions, it stated 'we eat far too much fat and starch and sugar and too little protein.' 'Protein and Carbohydrates', *The Philipsburg Mail*, 7 March 1895, Chronicling America: Historic American Newspapers.

88 One example is a list of foods by protein content published in US newspapers in 1917-1918. The message was directed at housewives, who were advised to identify how they could get the most protein for their money. United States Department of Agriculture, 'Foods Which Will Provide The Most Protein At Smallest Cost', *The Adair County News*, 2 January 1918, sec. Bulletins, Chronicling America: Historic American Newspapers.

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Pollan for the shift towards thinking of food solely in terms of nutritional content.[89] Where nutritional science began as a descriptive enterprise that looked at food culture from the outside, it increasingly played a role in creating it. The term 'protein' (or 'proteid') had first functioned to try to explain why people chose to eat what they did; increasingly, it was itself a reason for their food choices.

This was most obvious in the case of protein powders. With the invention of dried casein powder from skimmed milk in the 1890s, a whole category of protein-enhanced processed foods came into being.[90] The two most popular brands in Britain were Plasmon and Emprote, and both sold a range of high-protein biscuits, cocoa, chocolate and other products using claims about nourishment[91], body and brain health, testimonials from soldiers[92], strongmen[93], doctors, and food writers, and images of male bodies: in the case of Plasmon, images of heavily muscled body-builders; in the case of Emprote, the project of vegetarian tennis star Eustace Miles, images of athletes.[94]

Aberdeen Press and Journal - Tuesday 11 July 1911

The association between protein and masculinity had once been an indirect connection via meat, but by this point it was well established in its own right, and most of the customers of these brands were men. Advertising for protein foods mobilised the anxieties of the 'physical culture movement' prevalent in Germany, the US and the UK, fears that national masculinities were in the decline[95] and protein supplementation could help by building stronger bodies even more than by eating meat.[96] Adverts for Plasmon contrasted "red-blooded work-men" with enfeebled "brain workers", promoting what Conor Heffernan has described as a "somatic masculinity" through which nerves, brains and bodies weakened by

89 Gyorgy Scrinis, 'On the Ideology of Nutritionism', *Gastronomica* 8, no. 1 (1 February 2008): 39–48, https://doi.org/10.1525/gfc.2008.8.1.39; Michael Pollan, *In Defense of Food: An Eater's Manifesto* (New York: Penguin Press, 2008); Gyorgy Scrinis, *Nutritionism: The Science and Politics of Dietary Advice*, Arts and Traditions of the Table : Perspectives on Culinary History (New York, NY: Columbia Univ. Press, 2013).

90 Conor Heffernan, 'Superfood or Superficial? Plasmon and the Birth of the Supplement Industry', Journal of Sport History 47, no. 3 (2020): 243–62, https://doi.org/10.1353/sph.2020.0050; Lesley Steinitz, 'Transforming Pig's Wash into Health Food: The Construction of Skimmed Milk Protein Powders', *Global Food History*, 29 December 2021, 1–34, https://doi.org/10.1080/20549547.2021.2010977.

91 'Analysis proves that PLASMON CORN FLOUR contains 40 TIMES more proteid nourishment than ordinary Corn Flour. Ordinary Corn Flour--0.3% proteid. PLASMON 12.1%.' The International Plasmon Ltd., 'PLASMON CORN FLOUR', *Cornishman*, 6 July 1911, sec. Advertisement and Notices, British Library Newspapers, ezproxy-prd.bodleian.ox.ac.uk:2083/apps/doc/IG3223540295/BNCN?u=oxford&sid=bookmark-BNCN&xid=17ff06f1.

92 'AN ARMY SURGEON ... writes ... On "Black Monday" all our officers, twenty-three in number, carried three sticks of Plasmon Chocolate. None of us suffered the slightest, either from the heat or from the fatigue although we had breakfast at 5 30 a.m., and did not mess until 8 p.m.' The International Plasmon Limited, 'PLASMON CHOCOLATE', *Manchester Courier and Lancashire General Advertiser*, 10 May 1901, 77, 13885 edition, sec. Advertisement and Notices, British Library Newspapers, ezproxy-prd.bodleian.ox.ac.uk:2083/apps/doc/IG3220590141/BNCN?u=oxford&sid=bookmark-BNCN&xid=46309b46.

93 Heffernan, 'Superfood or Superficial?', 242,248.

94 Lauren Alex O'Hagan, 'Flesh-Formers or Fads? Historicizing the Contemporary Protein-Enhanced Food Trend', Food, *Culture & Society,* 18 June 2021, 1–24, https://doi.org/10.1080/15528014.2021.1932118.

95 Roberta J. Park, 'Muscles, Symmetry and Action: "Do You Measure up?" Defining Masculinity in Britain and America from the 1860s to the Early 1900s', *The International Journal of the History of Sport* 24, no. 12 (December 2007): 1604–36, https://doi.org/10.1080/09523360701619022; Heffernan, 'Superfood or Superficial?', 249; Steinitz, 'Transforming Pig's Wash into Health Food'; O'Hagan, 'Flesh-Formers or Fads?'

96 For example, in an advert for Sanatogen: 'Four teaspoonsful of Sanatogen ... yield as much protein nutriment as three-quarters pound of lean beef. ... being wholly absorbed, its body-building power is enormous.' Genatosan, Limited, 'The Remarkable Food Value of SANATOGEN: The Genuine Food Tonic', *Bath Chronicle and Weekly Gazette*, 3 January 1920, sec. Advertisements, The British Newspaper Archive.

sedentary lifestyles could be healed with exercise.[97] A secondary strand of advertising for these products aimed to appeal to women consumers, here typically focusing on caring identities as wives and mothers (even mocking women who stepped out of these traditional roles and evoking a familiar association between suffragettes and vegetarianism).[98]

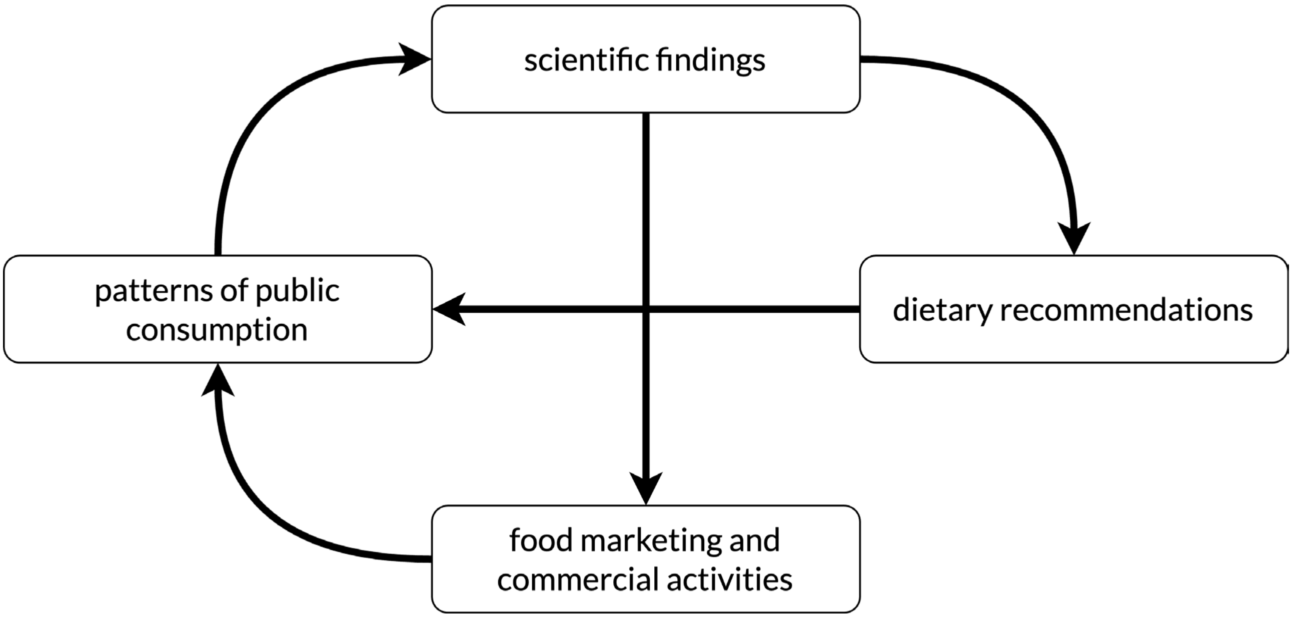

Figure 2. Feedback loop linking nutritional work on protein requirements to existing practice

97 Heffernan, 'Superfood or Superficial?', 251–52.

98 Heffernan, 253–55; For the links (perceived and actual) between the women's suffrage movement and vegetarianism, see Elsa Richardson, 'Cranks, Clerks, and Suffragettes: The Vegetarian Restaurant in British Culture and Fiction 1880–1914', *Literature and Medicine* 39, no. 1 (2021): 133–53, https://doi.org/10.1353/lm.2021.0010.

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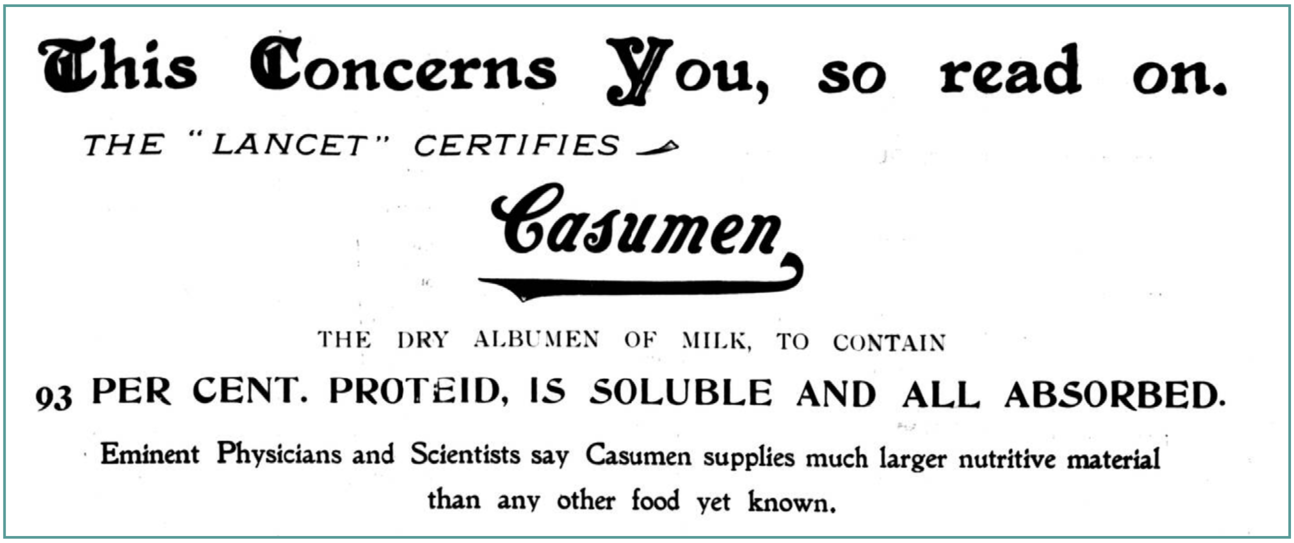

Bournemouth Graphic - Thursday 30 October 1902

3. Testing the lower limit: the end of the first protein fashion

Enthusiasm for protein in the latter half of the 19th century was a bubble—disconnected from the reality of research findings and driven by a series of feedback loops. The concept of protein as a single substance held such theoretical appeal that its influence was felt for decades after it was formally rejected. Research which established dietary requirements by measuring existing dietary habits took place in countries with cultural norms of high meat consumption. Beliefs about meat fitted neatly into ideologies of cultural, racial and national superiority—and the concept of protein established a seeming scientific basis for these beliefs. Scientists engaged in nutritional and agricultural research were often entrepreneurs, and findings that meat was healthsome and necessary offered the marketing tools to capitalise on a newly globalised and technologised meat market. In all of this, exaggerating the physiological importance of protein aligned with the interests of (commercial, social, national and racial) power.

All bubbles must burst in the end, and the seeds of protein doubt had been sown long before the end of the century. Max Rubner, as mentioned above, broke with his mentor Carl Voit and the reigning expert Liebig on protein requirements. He put more weight than they had on the experimental evidence against Liebig's theory of nutrition, and concluded that protein, fat and carbohydrate were largely interchangeable sources of dietary energy. By the early 20th century, he had suggested that the protein requirement for a male worker weighing 70kg might be as little as 30g of protein per day[99]—less than a quarter the value that he had given at an earlier point in his career, and far lower even than present-day estimates. This did not immediately result in a complete reassessment of the consensus, but it was part of a growing body of evidence complicating the earlier picture of protein. A gradually improving understanding of the chemistry of protein and new methods for exploring dietary requirements also contributed to this.

Since the mid-19th century, the growing vegetarian movement had offered an alternative narrative, both on protein and on meat. Prominent proponents of vegetarianism on religious grounds such as Presbyterian minister Sylvester Graham and later the Seventh Day Adventist J. H. Kellogg argued that consumption of meat led to overstimulation, bodily pollution and spiritual temptation. Kellogg (brother of W.K. Kellogg of breakfast cereal

99 Treitel, 'Max Rubner and the Biopolitics of Rational Nutrition', 6.

fame)[100] explained this as an effect of protein, and the idea that high protein consumption was dangerous developed in the discourse of a number of Christian denominations. In 1914, an advert for shredded wheat biscuits masquerading as an article on prison reform was published in a range of Christian publications in the US, and offers a telling example of the themes at play. The advert suggested that "an excess of high proteid foods" poisoned the blood, disturbed mental equilibrium, caused a "quarrelsome temperament" and might lead to "more heinous crimes".[101] [102]

Such beliefs had little direct impact on the scientific consensus, with nutritionists rejecting such diets as protein-deficient.[103] Proponents of vegetarianism were generally seen as cranks, and parodied variously as enfeebled, effeminate, and living dull lives of indigence. Nevertheless, there was a clear discrepancy between mainstream beliefs about protein and the existence of many people living on vegetarian diets—vegetarian restaurants had multiplied in cities like London and Manchester in the late 19th century—and this prompted researchers like Voit, Rubner, American biochemist Russel Henry Chittendon and Danish nutritionist Mikkel Hindhede to test whether bodily health could be maintained while eating less meat. Hindhede (whose work was also inspired by a desire to defend the potato-heavy but protein-light diet of his youth in rural Jutland)[104] published the results of experiments in which his lab assistant had been obliged to live on only potatoes, butter, and occasional fruit for a year—a diet, in other words, with no meat and no main source of protein. Although monotonous,[105] Hindhede claimed that this maintained him in "full vigor".[106] Hindhede found that this work—together with his earlier finding that *bovine* dietary requirements for protein were much lower than previously thought—was highly controversial in Denmark, leading him to publish a 1913 monograph condemning the work of the German nutritional school and attacking generally accepted views of protein. The book ("somewhat polemical" by its own admission[107]) concluded that "it would seem to be practically impossible to avoid getting protein enough"[108] and indeed that a high protein diet was "probably harmful". Although he stressed that he was not a vegetarian on principle, he would go on to advocate ovo-lacto vegetarianism as the healthiest diet for the remainder of his career.[109]

Perhaps the end of the fashion for protein was now an inevitability—or perhaps these arguments could have dragged on in the literature for many more years. However, the First World War created a dramatic break with

100 Carpenter, *Protein and Energy*, 79–88. J. H. Kellogg was actually the inventor of corn flakes, which he served at the sanatorium of which he was chief medical officer, but after a feud was forced to give up his rights to the invention to his brother. Kellogg is also credited with inventing peanut butter, and marketing an early meat substitute. Like Liebig and others, his beliefs about nutrition overlapped substantially with his entrepreneurial endeavours.

101 Dan Priel, 'Law Is What the Judge Had for Breakfast: A Brief History of an Unpalatable Idea', *Buffalo Law Review* 68, no. 3 (2020): 928–30.

102 Not all vegetarianism was religiously motivated by any means; for humanist vegetarians, however, the arguments were more about demonstrating the non-necessity of dietary animal protein than its actual harmfulness. Cf. Liam Young, 'Eating Serial: Beatrice Lindsay, Vegetarianism, and the Tactics of Everyday Life in the Late Nineteenth Century', *Societies* 5, no. 1 (22 January 2015): 65–88, https://doi.org/10.3390/soc5010065.

103 John M. Swan, 'A Study of the Metabolism of a Vegetarian', *The American Journal of the Medical Sciences* 129, no. 6 (June 1905): 1059; Carpenter, *Protein and Energy*, 88–99.

104 Mikkel Hindhede, *Protein and Nutrition: An Investigation* (London: Ewart, Seymour & Co., Ltd., 1913), 4–5.

105 For earlier researchers, the difficulty of finding test subjects willing to eat such restricted diets for a long period presented a significant barrier to this work—but, experimenting on his lab assistant and himself, Hindhede commented: "I have not encountered these difficulties." [Diesen Schwierigkeiten bin ich nicht begegnet.]

106 Mikkel Hindhede, 'Untersuchungen Über Die Verdaulichkeit Der Kartoffeln', *Skandinavisches Archiv Für Physiologie* 27, no. 2 (26 April 1912): 277–94; M. Hindhede, 'THE EFFECT OF FOOD RESTRICTION DURING WAR ON MORTALITY IN COPENHAGEN', *Journal of the American Medical Association* 74, no. 6 (7 February 1920): 381, https://doi.org/10.1001/jama.1920.02620060015005. Note that the experiment was not entirely continuous: there were periods in the summer where they could not get potatoes, and Hindhede wrote the work up as a series of slightly different experiments whose total period was over a year. However, in the 1920 paper he summarised it as having shown that 'man can retain full vigor for a year or longer on a diet of potatoes and fat', and this rather simplified image of the work has had a long afterlife in popular culture.

107 Hindhede, *Protein and Nutrition: An Investigation*, 4.

108 Hindhede, 156.

109 cf. M. Hindhede, 'Ueber den Einfluß der Nahrungsrationierung auf den Gesundheitszustand', *DMW - Deutsche Medizinische Wochenschrift* 46, no. 12 (March 1920): 318–20, https://doi.org/10.1055/s-0029-1192532.

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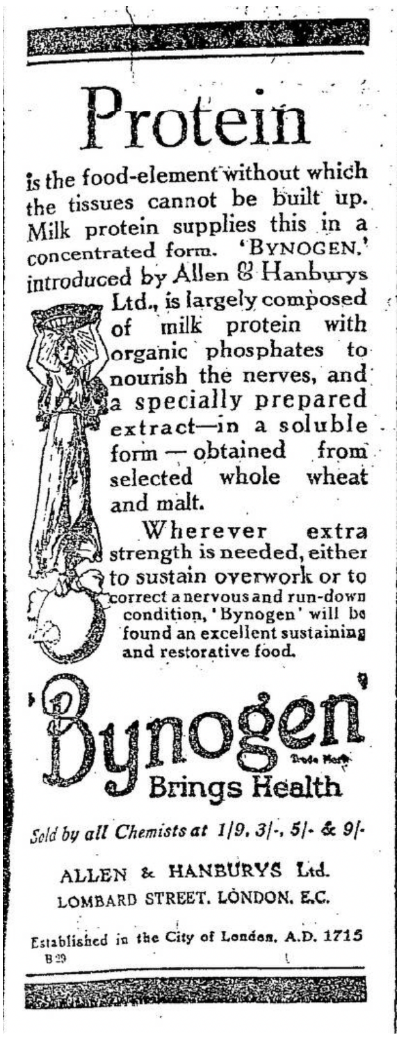
the past. The move to war economies in which states held monopsonies on food[110] created a need for governments to determine how much protein the agricultural sector should produce; blockades and rationing created a need to determine the minimum diets that could keep populations healthy. This led to greater power in the hands of nutritional scientists and a reification of nutritional science in the context of concrete goals and the opportunity to undertake experiments at enormous scale.

Rubner, heading the Kaiser Wilhelm Institut für Arbeitsphysiologie, was given authority by the German Ministry of War to investigate the role of nutrition in the optimal use of military and industrial labour. Hindhede, head of Denmark's Statens Laboratorium for Ernæringsundersøgelser, gained even greater authority. Thus two great critics of inflated demands for protein were given unprecedented platforms—but Rubner, who had vacillated on protein requirements over the course of his career, returned to the safe scholarly mainstream of assuming that diets should be high in protein[111] and so it was Hindhede's work that was transformative.

Towards the end of the war, the Danish state was affected by the Allied blockade and faced the challenge of avoiding the same disastrous famine that had already affected Germany. Hindhede centred the idea of feed-food competition[112] and recommended that 30-90% of pigs be allowed to starve so that lower quality cereals and vegetables normally used for feed could be repurposed as food. This policy, carried out, actually saw a *reduction* in human mortality through the period of rationing in Denmark. By contrast, Germany saw a precipitous rise in civilian deaths from starvation and disease—a disparity that completely vindicated both the arguments against high protein requirements and against the specific necessity of meat.[113] Hindhede wasted no time in highlighting this in international medical journals.[114]



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Following the War these findings were cemented with new methods of testing specific nutrient requirements in the lab—but Hindhede's views were becoming mainstream even earlier than this[115] and estimates of daily protein requirements

110 cf. Simmons, *Vital Minimum*, 110.

111 Mikuláš Teich, 'Science and Food during the Great War: Britain and Germany', in *The Science and Culture of Nutrition, 1840-1940*, ed. Harmke Kamminga and Andrew Cunningham (BRILL, 1995), 213–34, https://doi.org/10.1163/9789004418417; Corinna Treitel, 'Food Science/Food Politics: Max Rubner and "Rational Nutrition" in Fin-de-Siècle Berlin', in *Food and the City in Europe since 1800*, ed. P. J. Atkins, Peter Lummel, and Derek J. Oddy (Aldershot, England ; Burlington, VT: Ashgate, 2007), 59; Kristen Ehrenberger, 'The Politics of the Table: Nutrition and the Telescopic Body in Saxon Germany, 1890-1935' (Ph.D., Urbana, Illinois, University of Illinois, 2014), 61, https://www.proquest.com/docview/1624890978.

112 Helen Breewood and Tara Garnett, 'What Is Feed-Food Competition?', Foodsource: Building Blocks (University of Oxford: Food Climate Research Network, 2020), https://www.tabledebates.org/building-blocks/what-feed-food-competition.

113 Hindhede, 'THE EFFECT OF FOOD RESTRICTION DURING WAR ON MORTALITY IN COPENHAGEN'; Rabinbach, *The Human Motor*, 262–64; U Heyll, 'Der „Kampf ums Eiweißminimum"', *DMW - Deutsche Medizinische Wochenschrift* 132, no. 51/52 (12 December 2007): 2768–73, https://doi.org/10.1055/s-2007-1012767; Stephan Rössner, 'Mikkel Hindhede (1862-1945)', *Obesity Reviews* 11, no. 3 (March 2010): 231–32, https://doi.org/10.1111/j.1467-789X.2009.00636.x.

114 With the fuller view of hindsight, it is worth noting that historians now agree that Germany's disastrous experience of starvation in the War was more due to a lack of centralised planning of food and agriculture at all than to policies which privileged meat and protein. Rubner actually advocated similar policies to Hindhede: before the War he had argued that the poor should swap their meat for plant protein sources, and during the War he put a lot of focus on feed-food competition, writing 'If we had no pigs, we'd have no food worries. Perhaps we'll learn at least from the war, that swine husbandry is for the politics of food an example of insanity.' That German nutritional policies were so unsuccessful had much to do with problems of implementation. Nevertheless, the consensus interpretation in the following decades blamed Rubner, "rational nutrition", and proteincentricity. Heyll, 'Der „Kampf ums Eiweißminimum"', 2772; Treitel, 'Max Rubner and the Biopolitics of Rational Nutrition', 21–25; Ehrenberger, 'The Politics of the Table: Nutrition and the Telescopic Body in Saxon Germany, 1890-1935', 45.

115 Graham Lusk, *Food in War Time* (Philadelphia and London: W. B. Saunders Company, 1918); Henry C. Sherman, L. H. Gillett, and Emil Osterberg, 'Protein Requirement of Maintenance in Man and the Nutritive Efficiency of Bread Protein', *Journal of Biological Chemistry* 41, no. 1 (1920): 97–109.

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dropped precipitously (see Figure 4). Already in 1923, American nutritionist Lafayette Mendel was looking back on the 19th century obsession with protein,[116] commenting that long-disproven scientific ideas had left behind a public misconception of "momentous consequence" that "the production of 'flesh and blood' requires a liberal consumption of protein, which in turn is commonly interpreted to mean meat".[117] Hindhede, too, was establishing the narrative that the mists of an ideologically-sustained fixation on protein had finally lifted; he described one 19th century nutritionist of the German school as having written "with the manner of a propagandist" in advocating for the importance of protein.[118]

Nutritional science had broadly reached a consensus that protein requirements were far lower than previously believed and that meat consumption was not a physiological necessity—but this reassessment was tempered by other new research. The identification of individual amino acids had progressed (cf. Figure 3), and the discovery of the distinction between essential and non-essential amino acids through experiments on rats and dogs offered a possible explanation of civilian and military experiences of starvation[119] (particularly 'war dropsy' or 'war oedema', a condition involving swelling that was widespread in Europe—and would be again during the Second World War [120]). This strengthened a belief in the dietary importance of at least *some* level of intake of animal proteins, particularly milk.[121] What is more, the reassessment of protein and meat never consistently filtered out into other sciences or into public perception. In a 1939 American medical textbook we read that "the prowess and achievements of our early Anglo-Saxon ancestors have been attributed in part to the energy-giving effects of the meat which they consumed in liberal quantities [... and] if man would enjoy sustained vigor and would experience his normal expectancy, as well as contribute to the improvement of his race, he must eat a liberal quantity of good protein".[122] This quote clearly demonstrates the problem: all of the cognitive and cultural biases favouring protein and meat were still there. The power and influence of 'scientific consensus' is nothing against the power of a good story.

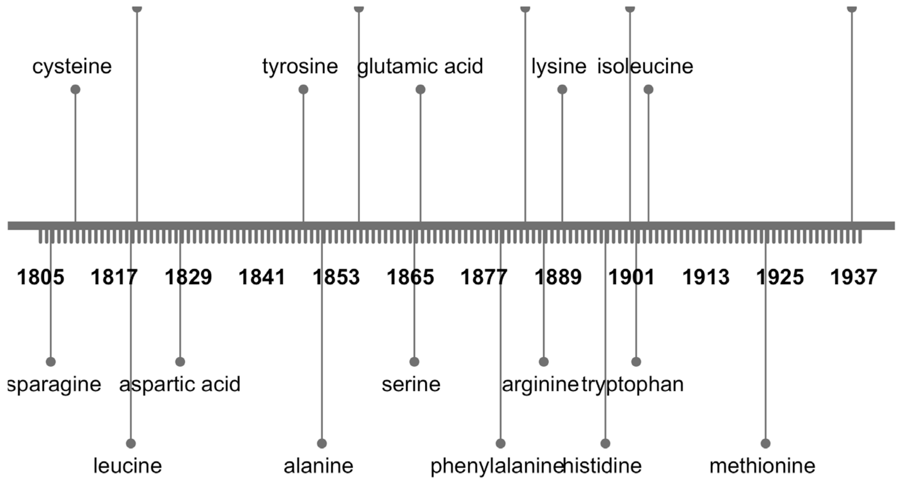

Figure 3: Timeline of identification of the amino acids

116 Lafayette B. Mendel, *Nutrition: The Chemistry of Life* (New Haven: Yale University Press, 1923), 14–26.

117 Mendel, 24.

118 Hindhede, Die Neue Ernährungslehre, 5, cited in Mendel, 113.

119 although these had equally been associated with excess intake of carbohydrate; cf. John Nott, '"No One May Starve in the British Empire": Kwashiorkor, Protein and the Politics of Nutrition Between Britain and Africa', *Social History of Medicine* 34, no. 2 (28 May 2021): 553–76, https://doi.org/10.1093/shm/hkz107.

120 F.A. Dentz, 'Hunger Oedema', *Acta Psychiatrica Scandinavica* 28 (June 1953): 93–112, https://doi.org/10.1111/j.1600-0447.1952.tb10987.x.

121 Food (War) Committee, *Report of the Food (War) Committee of the Royal Society on the Food Requirements of Man and Their Variations According to Age, Sex, Size, and Occupation* (London: Harrison and Sons, 1919), 18, https://wellcomecollection.org/works/w45wte5r; Mendel, Nutrition: The Chemistry of Life, 120–24.

122 James S. McLester, *Nutrition and Diet in Health and Disease* (Philadelphia: W. B. Saunders, 1939), 77.

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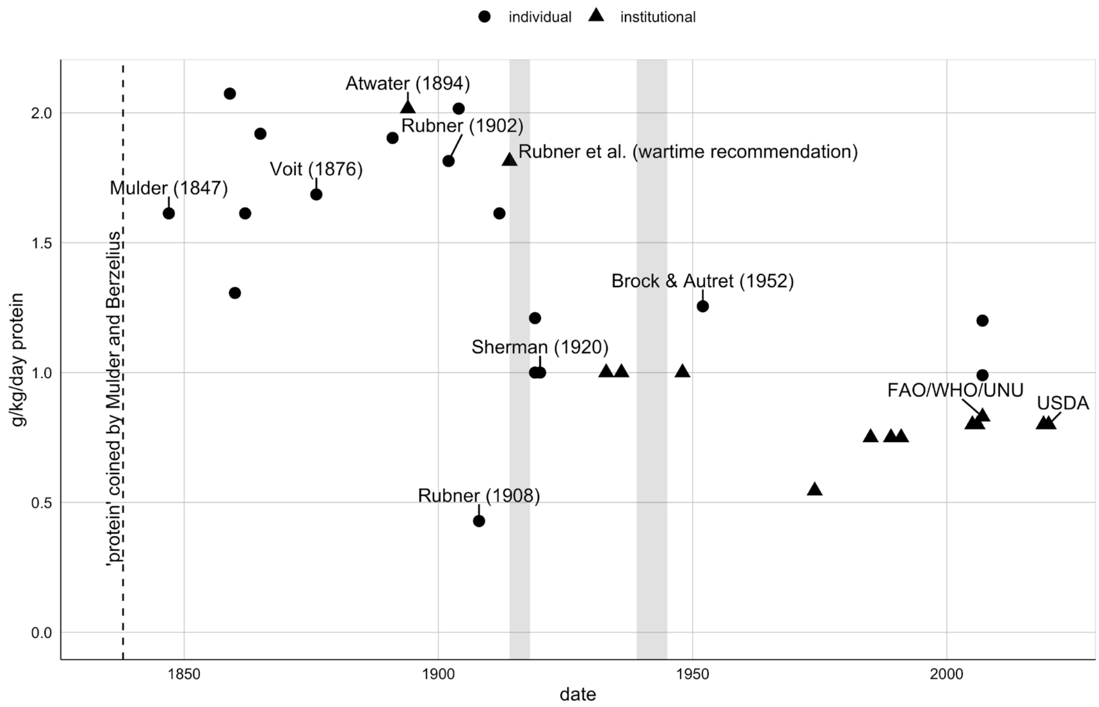

Figure 4. Recommendations by institutions and individual researchers for daily protein intake by body weight by year; recommendations mentioned in the text are individually labelled; shaded areas show the two world wars.[123]

123 Halliburton, *A Text-Book of Chemical Physiology and Pathology*, 604, 608; Max Rubner, *Die Gesetze des Energieverbrauchs bei der Ernährung* (Berlin u. Wien: F. Deuticke, 1902); Swan, 'A Study of the Metabolism of a Vegetarian'; David McCay, *The Protein Element in Nutrition* (London; New York: Edward Arnold; Longmans, Green & Co., 1912), 69, 110; Jules Amar, *The Physiology of Industrial Organisation and the Re-Employment of the Disabled*, trans. Bernard Miall (London: The Library Press Limited, 1918), https://archive.org/details/in.ernet.dli.2015.46478; Sherman, Gillett, and Osterberg, 'Protein Requirement of Maintenance in Man and the Nutritive Efficiency of Bread Protein'; Mixed Committee on the Problem of Nutrition, *The Problem of Nutrition*, vol. I: Interim Report of the Mixed Committee on the Problem of Nutrition (Geneva: League of Nations Publications Department, 1936); Kenneth L. Blaxter, 'The Purpose of Protein Production', in *The Biological Efficiency of Protein Production*, ed. John Gareth Watkin Jones (Cambridge: Cambridge University Press, 1973), 4; R. Passmore et al., *Handbook on Human Nutritional Requirements* (Geneva: World Health Organization, 1974), 20; Joint FAO/WHO/UNU Expert Consultation, 'Energy and Protein Requirements', World Health Organization Technical Report Series (Geneva: World Health Organization, 1985), 104–5; Subcommittee on the Tenth Edition of the RDAs, *Recommended Dietary Allowances* (Washington, D.C.: National Academy Press, 1989), 52–66; Cannon, 'Nutrition'; Jennifer J. Otten, Jennifer Pitzi Hellwig, and Linda D. Meyers, eds., *DRI, Dietary Reference Intakes: The Essential Guide to Nutrient Requirements* (Washington, D.C: National Academies Press, 2006); Mohammad A Humayun et al., 'Reevaluation of the Protein Requirement in Young Men with the Indicator Amino Acid Oxidation Technique', *The American Journal of Clinical Nutrition* 86, no. 4 (1 October 2007): 995–1002, https://doi.org/10.1093/ajcn/86.4.995; WHO, FAO, and UNU, eds., *Protein and Amino Acid Requirements in Human Nutrition: Report of a Joint WHO/FAO/UNU Expert Consultation*; [Geneva, 9 - 16 April 2002], WHO Technical Report Series 935 (Joint Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition, Geneva: WHO, 2007); Rajavel Elango et al., 'Evidence That Protein Requirements Have Been Significantly Underestimated':, *Current Opinion in Clinical Nutrition and Metabolic Care* 13, no. 1 (January 2010): 52–57, https://doi.org/10.1097/MCO.0b013e328332f9b7; Walter Willett et al., 'Food in the Anthropocene: The EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems', *The Lancet* 393, no. 10170 (February 2019): 447–92, https://doi.org/10.1016/S0140-6736(18)31788-4; U.S. Department of Agriculture and U.S. Department of Health and Human Services, *Dietary Guidelines for Americans 2020-2025.*

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4. 1918-1955: milk, aid and biopolitics

The 1900s and early 1910s had seen the foundation of many of the first international aid organisations and NGOs (see *Figure 5*); in the aftermath of the First World War, and with the establishment of the League of Nations Health Organization, these organizations came into greater prominence. They were initially focused on delivering food to war-torn Europe but, as Europe became more prosperous, 'world hunger' shifted to be seen as a characteristically African and Asian problem.[124] The realisation that malnutrition was a particular issue in the colonies created a political incentive for colonial powers to find a diagnosis that was not poverty or a simple lack of food: whereas impoverishment would seem to imply colonial maladministration, if the explanation was something specific to the cultures of colonised populations then colonial governance could not be to blame.[125] From the late 1920s onwards, this led to the renewal of the belief that many African and East Asian cultures suffered from a mistaken under-valuing of meat and dairy. Compounded by reports of the ignorance of mothers about infant nutrition, low intake of animal-sourced foods supposedly resulted in widespread protein deficiency.[126]

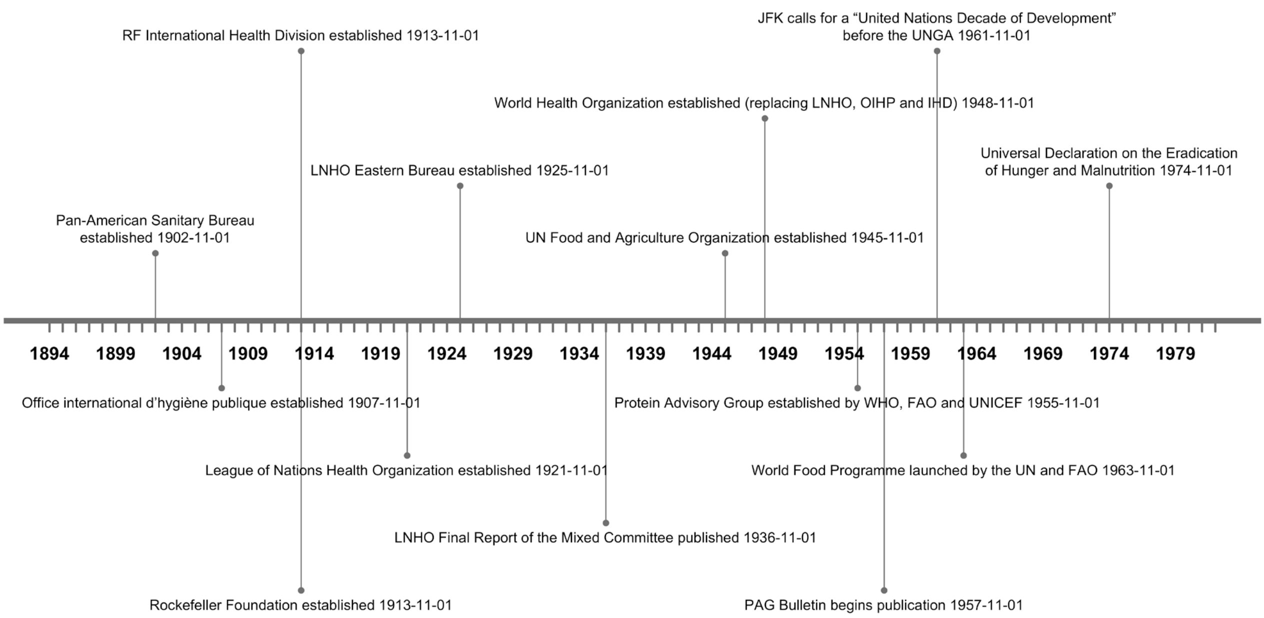

Figure 5: Timeline of important events in the history of international co-operation around nutrition and aid of relevance to the history of protein

124 Erica Marie Nelson, Nicholas Nisbett, and Stuart Gillespie, 'Historicising Global Nutrition: Critical Reflections on Contested Pasts and Reimagined Futures', *BMJ Global Health* 6, no. 11 (November 2021): e006337, https://doi.org/10.1136/bmjgh-2021-006337.

125 Nott, '"No One May Starve in the British Empire"', 567.

126 Michael Worboys, 'The Discovery of Colonial Malnutrition between the Wars', in *Imperial Medicine and Indigenous Societies*, ed. David Arnold (Manchester University Press, 2017), https://doi.org/10.7765/9781526123664.00013; Cynthia Brantley, 'Kikuyu-Maasai Nutrition and Colonial Science: The Orr and Gilks Study in Late 1920s Kenya Revisited', *The International Journal of African Historical Studies* 30, no. 1 (1997): 49, https://doi.org/10.2307/221546; Kimura, *Hidden Hunger*, 22.

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An important part of this story was a study by J. L. Gilks, Director of Medical Services in Kenya, and John Boyd Orr, Director of the Rowett Research Institute in Aberdeen. This work, first published in the Lancet in 1927 and as a longer report in 1931, compared the diets of the Maasai and Kikuyu peoples in Kenya. The Kikuyu suffered from persistent public health problems (in particular widespread tropical ulcer, a bacterial disease associated with poverty in tropical climates[127]) and had lower average height, weight and strength than the Maasai—this undermined their utility as a labour force.[128] Gilks & Orr characterised the Kikuyu as living "almost exclusively on a cereal diet",[129] eating meat only for ceremonial reasons ("indicating possibly a physiological craving"[130]), in contrast to the Maasai who lived "almost entirely on meat, milk and blood [...,] [an] exclusively protein diet".[131] They concluded that the difference in public health outcomes was due to the Kikuyu's 'vegetarian' diet. In retrospect, it is clear that these were not accurate characterisations of the diets; in addition, Gilks & Orr wrongly assumed that they were observing longstanding food practices unchanged by colonisation.[132] Nevertheless, over the 1930s, these findings were progressively projected and expanded to create an image of generalised cultural vegetarianism and consequent malnutrition among African agriculturalists.[133] This contradicted the stereotype of the hunting, meat-eating 'noble savage'—an image intertwined with thinking about human evolution and attached in particular to the Maasai.[134] [135] Apparently, however, the cultural imagination was able to tolerate any resulting cognitive dissonance.

The explanation of hunger as resulting from nutritional ignorance echoed domestic politics in wealthy countries. Throughout the 1920s and 30s, nutritional investigations and explanations put particular focus on newly-discovered vitamins and minerals. Often referred to as "protective foods", these were the nutrients *du jour* in the way that protein had been in the late 19th century, and it was feared that they were particularly lacking in modern, processed diets.[136] However, this advancing nutritional science also led to great optimism that problems of malnutrition could be fixed by changing practices rather than expending more resources: if a nutritionist could construct a hypothetical healthy diet containing all the necessary nutrients on a given budget, then money could

127 D. C. Robinson et al., 'The Clinical and Epidemiologic Features of Tropical Ulcer (Tropical Phagedenic Ulcer)', *International Journal of Dermatology* 27, no. 1 (January 1988): 49–53, https://doi.org/10.1111/j.1365-4362.1988.tb02339.x; Stefano Veraldi et al., 'Tropical Ulcers: The First Imported Cases and Review of the Literature', *European Journal of Dermatology* 31, no. 1 (February 2021): 75–80, https://doi.org/10.1684/ejd.2021.3968.

128 The Maasai, though healthier and larger, were "negligible" "[a]s a labour force" because "[t]heir interest is in cattle and nothing else, and apart from engaging as herdsmen they do not enlist for work."

129 J. L. Gilks and John Boyd Orr, 'The Nutritional Condition of the East African Native', *The Lancet*, 12 March 1927, 561.

130 Gilks and Orr, 561.

131 Gilks and Orr, 561.

132 Brantley, 'Kikuyu-Maasai Nutrition and Colonial Science'; Nott, '"No One May Starve in the British Empire"', 559.

133 Brantley, 'Kikuyu-Maasai Nutrition and Colonial Science', 52.

134 Dorothy L. Hodgson, '"Once Intrepid Warriors": Modernity and the Production of Maasai Masculinities', in *Gendered Modernities*, ed. Dorothy L. Hodgson (New York: Palgrave Macmillan US, 2001), 105–45, https://doi.org/10.1007/978-1-137-09944-0_5; Lotte Hughes, '"Beautiful Beasts" and Brave Warriors: The Longevity of a Maasai Stereotype', in *Ethnic Identity: Problems and Prospects for the Twenty-First Century*, ed. Lola Romanucci-Ross, George A. De Vos, and Takeyuki Tsuda, 4th ed (Lanham, MD: AltaMira Press, 2006), 264–94.

135 Even before the famous 'Man the Hunter' symposium in 1966, generations of anthropologists have discussed the role of hunting and meat-eating in human evolution—in short, to what extent '[H]uman hunting underlies humanness.' It is beyond the scope of this essay to go into these debates in any detail. Suffice it to say that the image of a (crucially) *male* human hunter is a recurring motif in both academic and popular thinking about pre-modern humans and in turn tends to shape conceptions of modern hunter-gatherers. It also undoubtedly plays a role in the primitivist strain of modern dieting culture that finds its expression in the Paleo Diet, the Carnivore Diet, and so on. Travis Rayne Pickering, *Rough and Tumble: Aggression, Hunting, and Human Evolution* (Berkeley: University of California Press, 2013), 8; Richard B. Lee and Irven DeVore, eds., *Man the Hunter: The First Intensive Survey of a Single, Crucial Stage of Human Development : Man's Once Universal Hunting Way of Life* (London: Taylor and Francis, 1968); Craig B. Stanford and Henry Thomas Bunn, *Meat-Eating & Human Evolution* (Oxford [England]: Oxford University Press, 2001); Christine Knight, 'Indigenous Nutrition Research and the Low-Carbohydrate Diet Movement: Explaining Obesity and Diabetes in *Protein Power*', *Continuum* 26, no. 2 (April 2012): 289–301, https://doi.org/10.1080/10304312.2011.562971; Dorsa Amir, 'A Viral Twitter Thread Reawakens the Dark History of Anthropology', Nautilus, 21 April 2022, https://nautil.us/a-viral-twitter-thread-reawakens-the-dark-history-of-anthropology-16408/.

136 Mixed Committee on the Problem of Nutrition, *The Problem of Nutrition*, 1936, I: Interim Report of the Mixed Committee on the Problem of Nutrition:15; Jia-Chen Fu, 'Confronting the Cow', in *Moral Foods: The Construction of Nutrition and Health in Modern Asia*, ed. Qizi Liang and Melissa L. Caldwell, Food in Asia and the Pacific (Honolulu: University of Hawai'i Press, 2019), 50.

not be the cause of dietary ill-health among the poor.[137] But in the international development sphere, this was just one of two competing views: the other, "progressive view" was to ascribe hunger to poverty, setting the blame firmly on colonial governments. The goal was a joined-up approach incorporating public health, nutrition, sanitation, education and the environment, and led by health professionals from Eastern Europe, South-East Asia and Latin America.[138] In 1933, the League of Nations Health Organization challenged member states to tackle the problem of colonial nutrition head on, stating that "there is more honour to be gained in attempting to improve the situation than in concealing it",[139] but the Health Organization's Mixed Committee, tasked with assessing the debate, tried to walk a line between the two approaches in its report *The Problem of Nutrition*, published in 1936.[140] This report would be highly influential for many years to come.

Gilks & Orr's study also engaged with high infant mortality rates. Again, they assigned these to dietary factors, first implying that they might be due to early weaning, but then concluding that this practice was itself a consequence of poor maternal nutrition.[141] This was part of a wider trend: the profile of maternal, infant and child nutrition in research rose throughout the 1920s and 30s, and with these the perceived dietary importance of cow's milk.

British governmentally-backed nutritional science during the First World War had concluded that "*no diet for* [infants and young children] *can be considered satisfactory which does not contain a considerable proportion of milk*";[142] since dairy production had been placed under state control, this put considerable pressure on governments to improve availability and prices. Influenced by reports of the cheaper, higher quality milk available to American consumers, pressure groups like the Women's Cooperative Guild organised boycotts and marches over the period 1917-1920, calling for the government to take action to lower milk prices.[143] During the 1920s, continued nutritional research—in particular, experimental studies which tested the effects of adding milk to the diet of institutionalised children—demonstrated that milk consumption promoted child growth, an idea that the dairy industry had already long been promoting in advertising.[144] [145] The equation of child growth with good health was well established in the thinking of nutritional science at this point, partly because labour and military

137 J. P. W. Rivers, 'The Profession of Nutrition—an Historical Perspective', *Proceedings of the Nutrition Society* 38, no. 2 (September 1979): 228, https://doi.org/10.1079/PNS19790035.

138 Tom Scott-Smith, *On an Empty Stomach: Two Hundred Years of Hunger Relief* (Cornell University Press, 2020), 75–89, https://doi.org/10.1515/9781501748677; Nelson, Nisbett, and Gillespie, 'Historicising Global Nutrition', 3.

139 E. Burnet and W. R. Aykroyd, 'Nutrition and Public Health', *League of Nations: Quarterly Bulletin of the Health Organisation*, no. 4 (1935): 452; cited in Nott, '"No One May Starve in the British Empire"', 560.

140 Mixed Committee on the Problem of Nutrition, *The Problem of Nutrition*, 1936; Technical Commission of the Health Committee, *The Problem of Nutrition*, vol. II: Report on the Physiological Bases of Nutrition (Geneva: League of Nations Publications Department, 1936); Mixed Committee on the Problem of Nutrition, *The Problem of Nutrition*, vol. III: Nutrition in Various Countries (Geneva: League of Nations Publications Department, 1936); Nelson, Nisbett, and Gillespie, 'Historicising Global Nutrition'.

141 Gilks and Orr, 'The Nutritional Condition of the East African Native', 561.

142 Food (War) Committee, *Report of the Food (War) Committee of the Royal Society on the Food Requirements of Man and Their Variations According to Age, Sex, Size, and Occupation*, 18 (emphasis original).

143 Deborah Valenze, *Milk: A Local and Global History* (New Haven & London: Yale University Press, 2011), 253–57.

144 Peter J. Atkins, 'Fattening Children or Fattening Farmers? School Milk in Britain, 1921–1941', *The Economic History Review* 58, no. 1 (2005): 61–62, https://doi.org/10.1111/j.1468-0289.2005.00298.x; Jon Pollock, 'Two Controlled Trials of Supplementary Feeding of British School Children in the 1920s', *Journal of the Royal Society of Medicine* 99, no. 6 (June 2006): 323–27, https://doi.org/10.1177/014107680609900624; Valenze, *Milk: A Local and Global History*, 260–62; Andrea S. Wiley, *Re-Imagining Milk*, The Routledge Series for Creative Teaching and Learning in Anthropology (New York: Routledge, 2011), 60,77-78.

145 Whether milk consumption has a particular effect on child growth beyond infancy is a complex issue. A century after these initial claims we can say that there is weak evidence for a small effect on lean body mass but not on height, but the question is far from settled. Nevertheless, a general *belief* that increasing milk consumption is a good way to promote child growth (and final adult height) is probably more widespread around the world today than it was in the twentieth century, since Western cultural beliefs about food have spread along with Western eating patterns in recent decades. Clear examples of this are found in government policies to increase milk consumption by children in order to promote growth in countries like China and Thailand which have little history of dairy consumption and where drinking milk has traditionally had very different (indeed, negative) connotations. On the related question of the effect of protein intake on *infant* growth, we can now say, contrary to assumptions through much of the 20th century, that there is none—at least within the range of protein contents in formulae and breastmilk. Wiley, *Re-Imagining Milk*, 78-84,96-102; D Joe Millward, 'Interactions between Growth of Muscle and Stature: Mechanisms Involved and Their Nutritional Sensitivity to Dietary Protein: The Protein-Stat Revisited', *Nutrients* 13, no. 3 (25 February 2021): 40–43, https://doi.org/10.3390/nu13030729.

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demands for taller bodies had played such a significant role in the development of nutritional science.[146] As a result, such findings represented unequivocal evidence for the necessity of milk. John Boyd Orr was also involved in this work, and was an enthusiastic milk advocate.[147]

The vehicle of motherhood and feminine care, milk carried a lot of symbolic potential. Given the focus on vitamins and protective foods, milk, a highly complex substance which could demonstrably serve as the sole source of nutrition for young mammals, seemed singularly promising; in the words of the Mixed Committee, it was "the nearest approach we possess to a perfect and complete food".[148] As already seen, because milk-drinking was not culturally universal it offered a useful rationalisation of imperial power and colonial ill-health. It fitted into a view of the world in terms of racial hierarchy in which white people were physically superior either due to or evidenced by their drinking milk.[149] Nor was the use of milk as a nationalist symbol unique to colonising countries: in India, the cow became a metaphor for the colonised state and milk-drinking a symbolic antidote for lost strength; thus here too a lack dairy consumption came to connote national weakness.[150]

Advertising played a major role in popularising positive links between milk, growth and strength. The idea that milk was a uniquely complete food had been utilised in adverts at least since the first milk-derived protein supplements at the turn of the century.[151] Lobbying and marketing bodies representing the dairy industry were set up in various countries, in many cases by the state. These included the US (the National Dairy Council, 1915), Sweden (the Milk Propaganda [Mjölkpropagandan], 1923, and later Swedish National Association of Dairies [Svenska Mejeriernas Riksförening], 1932), and Britain (the National Milk Publicity Council, 1920, and later the Milk Marketing Board, 1933), as well as Germany (1927), Finland (1927), Norway (1928), Japan (1931), Denmark (1932), Belgium (1938) and the Netherlands (1930s).[152] Some were highly influential, and repeated both the claims of nutritionists and racialised imagery and language in their advertising.[153] [154]

146 Cannon, 'Nutrition'; modern research is now complicating a neat equation of greater final height and better health, with, for example, higher incidence of some cancers among taller people. G. David Batty et al., 'Height, Wealth, and Health: An Overview with New Data from Three Longitudinal Studies', *Economics & Human Biology* 7, no. 2 (July 2009): 137–52, https://doi.org/10.1016/j.ehb.2009.06.004.

147 Atkins, 'Fattening Children or Fattening Farmers? School Milk in Britain, 1921–1941', 64.

148 Mixed Committee on the Problem of Nutrition, *The Problem of Nutrition*, 1936, I: Interim Report of the Mixed Committee on the Problem of Nutrition:58.

149 One 1933 textbook on agriculture stated that "[a] casual look at the races of people seems to show that those using much milk are the strongest physically and mentally, and the most enduring of the people of the world"; U. P. Hedrick, *A History of Agriculture in the State of New York* (New York: New York Agricultural Society, 1933); cited in E. Melanie DuPuis, *Nature's Perfect Food: How Milk Became America's Drink* (New York: New York University Press, 2002), 115.

150 Wiley, *Re-Imagining Milk*, 102–3.

151 For example, in an advert for Plasmon: 'Nature has elaborated one food, and only one. All others are merely adaptations. This food is milk.' The International Plasmon Ltd., 'PLASMON', *Manchester Courier*, 21 June 1901, sec. Advertisements, The British Newspaper Archive.

152 Carin Martiin, 'Swedish Milk, a Swedish Duty: Dairy Marketing in the 1920s and 1930s', *Rural History* 21, no. 2 (October 2010): 213–32, https://doi.org/10.1017/S0956793310000063.

153 DuPuis, *Nature's Perfect Food: How Milk Became America's Drink*, 117–18.

154 In an interesting example which unites the themes of milk-marketing and race, adverts by the Swedish Milk Propaganda in the 1920s and 30s often contrasted the lively and strong 'milk-boy [mjölkpojken]' with the weak 'coffee-boy [kaffepojken]'. A 1934 magazine article extolling milk-drinking was illustrated with children's drawings inspired by listening to a radio programme on health. In one, the

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Metropolitan Life Insurance Co. 1929 (Emergence of Advertising in America: 1850-1920, Duke University Libraries: CK0064)

They also presented milk consumption in terms of a battle between unhealthy, artificial modernity and healthy nature.[155] The line between the commercial activities of these groups and the public good was often blurred, with government-funded school milk programmes in Britain, Norway and the Netherlands partially motivated by the desire to find a profitable use for surplus milk production.[156]

The League of Nations' *The Problem of Nutrition* included the first League-backed estimates of dietary requirements. It prescribed 1 gram per kilogram of bodyweight per day for adults. This was in line with the scientific consensus since the end of the First World War, but unlike most previous official recommendations the report also gave a value for infants: 3.5 grams per kilogram of bodyweight per day.[157] Here, too, great emphasis was put on the importance of milk, especially for infant nutrition ("its value is unique and we cannot do without it") in terms which repeated the racist-colonial frame (milk characterised "the dietary of civilised peoples").[158]

The Second World War saw a repeat of the technocratic experiments of the First World War, with many European governments effectively nationalising food production and distribution through agricultural and horticultural programmes and rationing. These emergency measures lent prominence to nutritionists such as John Boyd Orr in Britain and led to a further reinforcement of the nutritional science of the time. As in Denmark in the First World War, countries like the Netherlands were able to partially mitigate threats to food security by rebalancing domestic food systems away from animal agriculture and towards cereals and potatoes.[159] In Britain, by contrast, much emphasis was put on the importance of milk—and successes in public health were confidently (although, in retrospect, erroneously) ascribed to this strategy.[160]

Milk was now intimately associated with the creation of big, strong bodies for war (in an address in 1943, Winston Churchill commented that "There is no finer investment for a community than putting milk into babies"[161])—and the creation of big, strong bodies continued to sit centre stage in the methods of nutritional science. As early as 1920, researchers had been aware of problems with one of the central tools of nutritional science, the study of the growth of young animals when fed different diets. Young animal growth was a singular, easily

coffee-boy has been transformed into a black boy, and the caption reads: 'You, nigger-boy, keep your coffee! And you, Swedish girl, drink good, white milk. [Du, negerpojke, behåll du ditt Kaffe! Och du, svenska flicka, drick du den goda, vita mjölken.]' Jenny Damberg, *Nu äter vi!: de moderna favoriträtternas okända historia*, 1. pocketutg (Stockholm: Ponto Pocket, 2015).

155 An example from a 1937 Swedish advert is particularly striking: "The rush of the age grips us. It forces us into an artificial way of life that will make us forget that we are yet children of nature with roots in the earth, and not mere cogs in a machine. Now more than ever we must find the power to resist in the sources of nature." ["Tidens jäkt griper omkring sig. Den tvingar oss in i en konstlad livföring, som kommer oss at glömma, att vi trots allt äro naturens barn med rötter i jorden och icke blott kuggar i ett maskineri. Nu mer än någonsin måste vi hämta motståndskraft ur naturens källor."] Svenska Mejeriernas Riksförening, 1937, and cf. Figure 6.

156 Atkins, 'Fattening Children or Fattening Farmers? School Milk in Britain, 1921–1941'; A. Andresen and K. T. Elvbakken, 'From Poor Law Society to the Welfare State: School Meals in Norway 1890s-1950s', *Journal of Epidemiology & Community Health* 61, no. 5 (1 May 2007): 374–77, https://doi.org/10.1136/jech.2006.048132.

157 Technical Commission of the Health Committee, *The Problem of Nutrition*, II: Report on the Physiological Bases of Nutrition:15.

158 Mixed Committee on the Problem of Nutrition, *The Problem of Nutrition*, 1936, I: Interim Report of the Mixed Committee on the Problem of Nutrition:58.

159 M. J. L. Dols and D. J. A. M. van Arcken, 'Food Supply and Nutrition in the Netherlands during and Immediately after World War II', *The Milbank Memorial Fund Quarterly* 24, no. 4 (October 1946): 319, https://doi.org/10.2307/3348196.

160 Rivers, 'The Profession of Nutrition—an Historical Perspective', 229–30; Cannon, 'Nutrition', S484.

161 Valenze, *Milk: A Local and Global History*, 254.

measurable metric—but one that would be especially sensitive to the nutrients required for tissue production and might be insensitive to those needed for other bodily functions. Assuming growth was an indicator of the total relationship between health and diet might thus be expected to overemphasise protein requirements and special requirements for particular amino acids.[162] This lesson had not been learnt. In a telling example, post-war research by British nutritionists McCance & Widdowson (both of whom had been deeply involved in the government's wartime effort) demonstrated that child growth was insensitive to the choice of brown or white bread.[163] This was taken to imply that, contrary to general belief, brown and white bread were nutritionally identical, prompting the British government to acquiesce to demands from the baking and milling industries for the freedom to produce white bread instead of brown.[164] [165]

Figure 6: Svenska Mejeriernas Riksförening advert for dairy products, 1937.

The seeming success of wartime technocratic approaches to nutrition and rationing in the Allied countries helped to push back against the idea that world hunger and particularly colonial malnutrition were problems of poverty. Nevertheless, in the aftermath of the Second World War, the contestation between technocratic and social approaches continued in the new United Nations institutions. US actors in particular tended to push for vertical, technocratic solutions to famine relief and other public health problems, which allowed them to make use of military expertise developed during the war.[166] In many ways, patterns seen after the First World War repeated: initially the problem of hunger was global and remedial efforts were focused on Europe; when the European situation was stabilised the focus shifted to Africa, Asia and South America, and with this shift, the politics changed.[167]

The scene was now set for protein to return to the fore.

162 Sherman, Gillett, and Osterberg, 'Protein Requirement of Maintenance in Man and the Nutritive Efficiency of Bread Protein', 106–7.

163 Robert Alexander McCance and E. M. Widdowson, 'Old Thoughts and New Work on Breads White and Brown', *The Lancet* 269 (1955): 205–10.

164 White bread was financially more profitable for commercial bakeries for several reasons: it suited their machines; had a longer shelf-life; and it allowed them to sell the bran and wheatgerm separately for use in animal feed and as an input to the production of nutritional supplements.

165 Cannon, 'Nutrition', S483.

166 Nelson, Nisbett, and Gillespie, 'Historicising Global Nutrition', 4.

167 Cannon, 'Nutrition'; Kimura, *Hidden Hunger*, 23.

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5. Protein fiasco

In 1933, Cicely Williams, a doctor in the British Colonial Medical Service posted to the Gold Coast (modern-day Ghana), had published a paper describing a disease afflicting children in her care. The disease caused oedema (swelling), wasting, diarrhoea, sores, discolouration and loss of patches of skin, and eventually death. It typically affected children a short while after weaning, particularly in cases where the child was mainly living on maize. Williams suspected the cause was dietary and had been giving an inpatient treatment diet including Marmite, fruit, cod-liver oil, tinned milk and malt. Her impression was that "the most important elements in the treatment" were the cod-liver oil and milk, and she recommended treatment with Nestlé's sweetened condensed milk.[168] Commenting on the association with a maize diet she cautiously stated only that "some amino acid or protein deficiency cannot be excluded as a cause."[169] Two years later she published a further paper rebuffing criticism[170] that she was just misdiagnosing pellagra (vitamin B3 deficiency) and naming the condition *kwashiorkor*, a term borrowed from the Gã language which she explained "indicates the disease the deposed baby gets when the next one is born."[171]

Williams' work didn't get much attention at first. Few other scholars cited her papers or used the term kwashiorkor, and in 1936 she was transferred to Malaya.[172] Other scholars continued to study the disease but accepted neither Williams' name for it nor the suggestion that it was due to an amino acid or protein deficiency—instead, they explored the idea that this was a peculiar infant presentation of pellagra or that malnutrition was just one component of a complex of causes.[173] The choice of name may have undermined her credibility—as her identities as a woman and as a medical practitioner rather than a researcher certainly did. But after the war, this was to change.

In 1949, the newly-founded World Health Organization (WHO) and Food and Agriculture Organization (FAO), picking up the role of the LNHO, met to co-ordinate their work on nutrition. One item on the agenda was "a syndrome at present ill-defined" but "[o]ne of the most widespread nutritional disorders in tropical and sub-tropical areas", particularly affecting infants and young children in "some parts of Africa".[174] The committee listed a series of names used for this syndrome but gave the agenda item the heading "Kwashiorkor" (in quotation marks). They offered no definitive account of its aetiology, mentioning cirrhosis of the liver, the diets of mothers and children, and tropical parasitism as points on which to focus further research. In their next agenda item, however, they discussed problems of malnutrition in young children after weaning "in some countries" more broadly, and emphasised that they believed these were particularly due to lack of (cows') milk.[175]

The inverted commas around the word kwashiorkor, the list of other possible names and lack of a singular diagnosis show that expert opinion had yet to settle: the reader gets the impression that the choice of the name 'kwashiorkor' (and not, for example, 'polydeficiency disease') for the heading was arbitrary. However, a focus on this particular presentation of poor infant health and a set of associations with milk and inferred specific nutrient deficiencies were clearly developing. Over the following few years, various WHO and FAO studies added to the

168 Cicely D. Williams, 'A NUTRITIONAL DISEASE OF CHILDHOOD ASSOCIATED WITH A MAIZE DIET', *Archives of Disease in Childhood* 58 (1933): 559.

169 Williams, 559.

170 H. S. Stannus, 'A Nutritional Disease of Childhood Associated with a Maize Diet--and Pellagra', *Archives of Disease in Childhood* 9, no. 50 (1 April 1934): 115–18, https://doi.org/10.1136/adc.9.50.115.

171 Cicely D. Williams, 'KWASHIORKOR', *The Lancet* 226, no. 5855 (November 1935): 1151–52, https://doi.org/10.1016/S0140-6736(00)94666-X.

172 Carpenter, *Protein and Energy*, 142–45; Joshua Nabilow Ruxin, 'Hunger, Science, and Politics: FAO, WHO, and Unicef Nutrition Policies, 1945-1978' (Ph.D., London, University College London, 1996), 37; Kimura, *Hidden Hunger*, 23.

173 Carpenter, *Protein and Energy*, 145–49; Nott, '"No One May Starve in the British Empire"', 566.

174 Joint FAO/WHO Expert Committee on Nutrition, *Joint FAO/WHO Expert Committee on Nutrition: Report on the First Session, Geneva, 24-28 October 1949.* (Geneva: World Health Organization, 1950), 15.

175 Joint FAO/WHO Expert Committee on Nutrition, 16.

impression that kwashiorkor was a widespread problem—not only in children but also in adults, and not only in Africa but also in South America and India.[176] Just as Cicely William's work had before the war, many of these studies focused on the 'exotic' diets of the populations under study, with high consumption of maize and starchy roots and low consumption of animal proteins. Quickly, the consensus shifted towards seeing kwashiorkor as the result of protein deficiency. Particularly influential was a 1952 study by J. F. Brock (of the WHO) and M. Autret (of the FAO) entitled 'Kwashiorkor in Africa', which concluded that none of the traditional foodstuffs of the areas they had studied contained enough protein to meet the needs of newly-weaned infants,[177] [178] and that the only ethnic groups that did not suffer from the disease were those who consumed large quantities of cows' milk.[179] The sense of alarm around kwashiorkor grew, and in 1955, the WHO's Nutrition Section stated that "kwashiorkor is without doubt the most important nutritional public health problem of the present time".[180] In the same year, the UN established a special Protein Advisory Group.[181] The stage was thus set for nearly two decades of myopic focus on protein in international development.

An important concept informing discourse through this period was that of the 'protein gap': the gap between the amount of protein needed to maintain the world population in good health and the amount actually being produced. Part of this was a projection into the future: current agriculture would not be able to produce enough protein to feed everyone as the world population expanded. But it was rooted in beliefs about current, endemic undernutrition. Even if it was acknowledged that some communities were straightforwardly *short of* food rather than eating the *wrong* foods, it was argued that the best way to solve both problems concurrently was by producing more protein: after all, this would also entail producing more calories.

This was world hunger understood through the frame of nutritional science—not as a social problem in need of a political response, but as a scientific problem in need of a technological solution. Initially, it seemed that this technology might be milk. Williams had identified tinned milk as a possible cure for kwashiorkor from the beginning, and even those who believed there was more to the disease than simple protein deficiency recommended skimmed milk powder as treatment.[182] Interest developed in protein quality, and milk was proposed as the reference protein for determining amino acid requirements in young children at the second conference on protein malnutrition in 1955.[183] UNICEF had already been distributing skimmed milk powder as part of work to alleviate postwar hunger in Europe, so increasing consumption of skimmed milk seemed like the ideal cure.[184] In countries like the UK and US, milk still had great symbolic power as the vehicle of feminine domestic care (Milk Marketing Board slogans at the time included "is your man getting enough?"[185])—given that kwashiorkor was often framed as a maternal failing, it seemed an apt solution. However, WHO and FAO policymakers quickly concluded that increasing dairy production in Africa was impractical, and the population in need was too poor to

176 Carpenter, *Protein and Energy*, 149; Richard D. Semba, 'The Rise and Fall of Protein Malnutrition in Global Health', *Annals of Nutrition and Metabolism* 69, no. 2 (2016): 80, https://doi.org/10.1159/000449175.

177 J. F. Brock and M. Autret, 'KWASHIORKOR IN AFRICA', *Bulletin of the World Health Organization* 5 (1952): 1–71 particularly cf. 49.

178 Indeed, even human breastmilk was judged too low in protein for infants—which in retrospect should perhaps have rendered the results suspect. Apparently the idea that it was normal good practice to supplement infant feeding with (higher protein) cow's milk was so deeply accepted that this passed without comment.

179 Semba, 'The Rise and Fall of Protein Malnutrition in Global Health', 80.

180 Ruxin, 'Hunger, Science, and Politics: FAO, WHO, and Unicef Nutrition Policies, 1945-1978', 72.

181 Semba, 'The Rise and Fall of Protein Malnutrition in Global Health', 81.

182 Brock and Autret, 'KWASHIORKOR IN AFRICA', 29.

183 Semba, 'The Rise and Fall of Protein Malnutrition in Global Health', 80.

184 Kimura, *Hidden Hunger*, 24; Richard D. Semba, 'The Historical Evolution of Thought Regarding Multiple Micronutrient Nutrition', *The Journal of Nutrition* 142, no. 1 (1 January 2012): 148S, https://doi.org/10.3945/jn.110.137745.

185 Lindsay Hamilton, Marylyn Carrigan, and Camille Bellet, '(Re)Connecting the Food Chain: Entangling Cattle, Farmers and Consumers in the Sale of Raw Milk', *The Sociological Review* 69, no. 5 (September 2021): 1107–23, https://doi.org/10.1177/0038026121990975; it is also interesting to note that the 'Special Milk Program' began distributing milk to school children in the US in 1954 - Susan Levine, *School Lunch Politics: The Surprising History of America's Favorite Welfare Program*, Course Book (Princeton, NJ: Princeton University Press, 2011), 93.

afford imports. What was needed was a protein-rich food that could be made cheaply, from local ingredients.[186] A founding aim of the Protein Advisory Group was to help find "new protein foods",[187] and in 1960 it established the Committee on Protein Malnutrition (funded to the tune of $880k by UNICEF and the Rockefeller Foundation) to focus on furthering this goal.[188] The Group put out calls for research into unconventional sources of protein for human consumption during the 1960s,[189] but national governments, UN agencies and private companies had started exploring possible new technologies from an even earlier point.

In the late 1950s, the Chilean and South African governments pursued a project to create a flavourless protein flour from fish. This involved drying and powdering huge quantities of small fish, and removing the fat by centrifuge and by extraction using ethanol and hexane. The resulting meal could be added in small quantities to bread flour. This was done in South Africa at government expense from 1956 to 1959, but stopped when it was realised that the population at risk from kwashiorkor ate very little bread. The Chilean government project was then abandoned in 1961 due to engineering problems, without ever reaching the distribution stage.[190] The US Bureau of Commercial Fisheries pursued a similar project throughout the 1960s, even building a pilot plant and then a production plant—but eventually abandoned it, both due to regulatory barriers and because the fish stocks the project relied on collapsed.[191] None of the US-produced fish flour was ever distributed.

Other techno-protein projects focused on culturing yeasts, bacteria and fungi. The idea was that this 'single-cell protein' (SCP) could be grown on a feedstock that was indigestible to humans—or at least was abundant and low in protein—and thus very cheap. The technology for growing SCP on various crude oil and petroleum derivatives was developed in France in the late 1950s by British Petroleum, and many commercial projects followed. The names alone tell the strange story of the era: 'Toprina' by BP in France and the UK, 'Topriana' and 'Liquipron' in Italy, 'Roniprot' in Romania, 'Torutein' in the US—all based on strains of *candida* yeasts. 'Fermosin', 'Probion', 'Pruteen' and 'Norprotein' based on various bacteria in Germany, the UK and Norway/Sweden.[192] However, after the 1973 oil crisis the price of crude oil was too high for growing SCP on petrochemicals to make economic sense.[193] Other SCP projects grew their putatively edible microbes on different substrates: waste woodchips and sawdust

Specimen of "Toprina" single cell protein, 1977, as produced by B.P. Ltd. at Grangemouth; in argon-filled sealed glass flask (Science Museum Group Collection Online, 1977-438)

186 Carpenter, *Protein and Energy*, 152–53.

187 Protein Advisory Group, 'Lives in Peril: Protein and the Child', World Food Problems (FAO/WHO/UNICEF, 1970).

188 Semba, 'The Rise and Fall of Protein Malnutrition in Global Health', 81.

189 Pauline K. Marstrand, 'Production of Microbial Protein: A Study of the Development and Introduction of a New Technology', *Research Policy* 10, no. 2 (July 1981): 168, https://doi.org/10.1016/0048-7333(81)90003-2.

190 Carpenter, *Protein and Energy*, 163–64.

191 Carpenter, 165–68; Ernst R. Pariser et al., *Fish Protein Concentrate: Panacea for Protein Malnutrition?*, International Nutrition Policy Series 3 (Cambridge, Mass: MIT Press, 1978).

192 Richard Westlake, 'Large-scale Continuous Production of Single Cell Protein', *Chemie Ingenieur Technik* 58, no. 12 (1986): 934–37, https://doi.org/10.1002/cite.330581203; I. Y. Hamdan and J. C. Senez, 'The Economic Viability of Single Cell Protein (SCP) Production in the Twenty-First Century', in *Biotechnology: Economic and Social Aspects*, ed. E. J. DaSilva, C. Ratledge, and A. Sasson, 1st ed. (Cambridge University Press, 1992), 142–64, https://doi.org/10.1017/CBO9780511760075.008.

193 Marstrand, 'Production of Microbial Protein'.

from forestry, waste liquor from paper mills (an important example was Finnish 'Pekilo'[194]), waste sugar from confectionary production (by Tate & Lyle in the UK[195]), molasses as a by-product of sugar refinement, whey as a by-product of dairy processing, and ethanol from various sources.[196]

Some of these projects did achieve a significant scale, both in the West and the USSR—by the 1980s, the Soviet Union was reporting production of over a million tonnes of SCP per year.[197] What they did not do was solve world hunger or the protein gap. Many SCPs have a higher proportion of nucleic acids than other proteins, and it turned out that humans lack the digestive enzyme possessed by other mammals needed to process nucleic acids in large quantities.[198] This puts a limit on the proportion of dietary protein that can come from SCPs. On top of this, many SCPs were found to produce allergic reactions in a substantial minority of human test subjects. Aside from the health concerns, SCP production required a level of sterilisation and contamination control that challenged contemporary engineering—these were not technologies suited to low-cost expansion to poor areas.[199] As a result, the vast majority of SCP was used as an additive in animal feed in developed countries, not as food in developing countries.

One partial exception was Quorn, a British brand of mycoprotein derived from the *fusarium venenatum* fungus[200] and developed in a collaboration between Rank Hovis McDougall and Imperial Chemical Industries building on infrastructure from ICI's 'Pruteen' process.[201] Development of Quorn started in 1964 in response to concerns about the protein gap and it remains a highly successful brand of vegetarian meat substitute today, especially in the EU and UK. However, in two senses, this was the exception that proved the rule: it was not grown on cheap waste products but on wheat;[202] and it did not come to market until 1985, after international interest in protein had waned.[203]

Other techno-protein projects included oilseed flours, peanut flour, peanut milk, soybean flour, fortified chocolate soy milk, cottonseed flour, leaf protein concentrate, synthetic amino acids and lysine-enhanced wheat, maize

194 Juha Koivurinta, Rakel Kurkela, and Pekka Koivistoinen, 'Uses of Pekilo, a Microfungus Biomass from Paecilomyces Varioti in Sausage and Meat Balls', *International Journal of Food Science & Technology* 14, no. 6 (December 1979): 561–70, https://doi.org/10.1111/j.1365-2621.1979.tb00902.x.

195 A. J. Forage, 'III Utilization of Agricultural and Food Processing Wastes Containing Carbohydrates', *Chemical Society Reviews* 8, no. 2 (1979): 309, https://doi.org/10.1039/cs9790800309.

196 Hamdan and Senez, 'The Economic Viability of Single Cell Protein (SCP) Production in the Twenty-First Century'; M. García-Garibay et al., 'SINGLE CELL PROTEIN | Yeasts and Bacteria', in *Encyclopedia of Food Microbiology* (Elsevier, 2014), 431–38, https://doi.org/10.1016/B978-0-12-384730-0.00310-4.

197 Hamdan and Senez, 'The Economic Viability of Single Cell Protein (SCP) Production in the Twenty-First Century', 146; García-Garibay et al., 'SINGLE CELL PROTEIN | Yeasts and Bacteria', 431.

198 Specifically, humans and some related primates have lost the ability to produce urate oxidase. As a result, purines, including adenine and guanine which are components of DNA, are only metabolised into uric acid in humans instead being further oxidised. High blood levels of urates are then associated with gout and kidney stones. X W Wu et al., 'Urate Oxidase: Primary Structure and Evolutionary Implications.', *Proceedings of the National Academy of Sciences* 86, no. 23 (December 1989): 9412–16, https://doi.org/10.1073/pnas.86.23.9412; Carpenter, *Protein and Energy*, 176.

199 Carpenter, *Protein and Energy*, 175–77.

200 Mycoprotein derived from Fusarium venenatum has now even been suggested as the new standard for high quality dietary protein against which other sources should be judged. The species name—*Fusarium venenatum* is Latin for 'venomous spindle'—seems a little ironic in retrospect. D Joe Millward, 'Milk Protein Loses Its Crown?', *The American Journal of Clinical Nutrition* 112, no. 2 (1 August 2020): 245–46, https://doi.org/10.1093/ajcn/nqaa112.

201 Jack A. Whittaker et al., 'The Biotechnology of Quorn Mycoprotein: Past, Present and Future Challenges', in *Grand Challenges in Fungal Biotechnology*, ed. Helena Nevalainen, Grand Challenges in Biology and Biotechnology (Cham: Springer International Publishing, 2020), 59–79, https://doi.org/10.1007/978-3-030-29541-7_3.

202 Note that Quorn Foods Ltd. claims that their process creates more protein per tonne of wheat than was contained in the wheat: thus quorn as a technology could theoretically still increase the availability of protein, even though it is grown on feedstock that humans could eat. I have not been able to precisely reproduce these calculations, however. Quorn Foods Ltd., 'Quorn Sustainable Development Report 2017' (Stokesley, North Yorkshire, 2017), 14–15, https://www.quorn.co.uk/files/content/Sustainable-Development-Report-2017.pdf.

203 Anthony P.J. Trinci, 'Myco-Protein: A Twenty-Year Overnight Success Story', *Mycological Research* 96, no. 1 (January 1992): 1–13, https://doi.org/10.1016/S0953-7562(09)80989-1; T. Sharp, 'Quorn Myco-Protein: The Development of a New Food and Its Contribution to the Diet', in *Food and Nutrition Policy in Europe* (The Second European Conference on Food and Nutrition Policy, The Hague 21 - 24 April 1992, Wageningen: Pudoc Scientific Publishers, 1993), 149–54.

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and rice flours, as well as various projects involving skimmed milk.[204] Not all of these ventures were completely without results, but none had any substantial effect on hunger in developing countries or on infant malnutrition. A post-mortem co-written by one of the scientists involved in the US work on fish flour[205] suggests several reasons for these failures. For one thing, the incentives were not well aligned, with US and European entrepreneurs favouring projects with the potential to be profit-making and US and European government agencies favouring projects which made for good publicity. Both of these groups were keen to find profitable uses for surplus Western produce—particularly fish and milk.[206] In the case of fish and petroleum derivatives, projects were built on assumptions about the abundance of inputs that turned out to be wrong. In almost all of these cases, foods were being designed with no reference to the food cultures of the people they were supposed to help, and little reference to economics or the availability of infrastructure for delivery. It is important to note that none of this is to imply that these projects were carried out under false pretences. Scientists and engineers, aid workers and their institutional backers, entrepreneurs and those in corporate governance—all were urgently trying to respond to real and affecting humanitarian need. Rather, systemic and cultural forces channelled these efforts into ineffectual and even irrelevant projects.

Some protein technologies developed in this period did achieve lasting success, even if they did little to solve the problem of world hunger. In 1965, the Archer Daniels Midland company filed a patent for a dried, textured protein food made from soybeans[207] which they would later trademark TVP ('textured vegetable protein').[208] In the same year, the company took on new leadership in the person of Dwayne Andreas, previously an executive in soy oil processing. Andreas had the "zeal of a missionary for bringing cheap protein to consumers" and liked to "talk about protein shortages and world food problems".[209] He sold Archer Daniels Midland's $65m chemical division to free up capital and concentrate on soy processing, a decision that would prove lucrative; importantly, the USDA's Agricultural Research Service would approve the use of TVP to bulk out or replace meat in US school lunches in 1971, creating a huge domestic market.[210] Another soy derivative, 'spun soy protein' from General Mills, had been trademarked 'Bontrae' a few years earlier,[211] although it would not achieve the same degree of lasting commercial success.

These companies presented new protein foods not merely as commercial ventures but as vehicles of social good. If nothing was done then "many millions yet unborn [would] die from the consequences of malnutrition", but since "even starving people are funny about food," inventions were needed to make cheap proteins resemble familiar foods[212]—specifically, to create analogues of meat.[213] Private enterprises of this type were lauded by government actors, operating on the assumption that domestic commercial success was the necessary precursor to wider

204 Aaron M. Altschul, *Combating Malnutrition: New Strategies through Food Science, Remarks of Aaron M. Altschul, Special Assistant for International Nutrition Improvement to Secretary of Agriculture, to 2nd Joint Meeting of American Institute of Chemical Engineers and Institute de Ingenieros Quimicos de Puerto Rico, Tampa, Fla., May 21, 1968* (Washington, D.C: U.S. Dept. of Agriculture, 1968); Carpenter, *Protein and Energy*, 161–78; Semba, 'The Rise and Fall of Protein Malnutrition in Global Health', 82–84.

205 Pariser et al., *Fish Protein Concentrate*.

206 Pariser et al., 52, 225–29; Edward Clay, 'Book Review Article: Forty Years of Multilateral Food Aid: Responding to Changing Realities', *Development Policy Review* 20, no. 2 (2002): 203–7; Kimura, *Hidden Hunger*, 24.

207 Francis E Calvert and William T Atkinson, PROCESS FOR THE PREPARATION OF HYDRATABLE PROTEIN FOOD PRODUCTS, United States Patent and Trademark Office US 3498794 A, filed 25 January 1965, and issued 3 March 1970.

208 Archer Daniels Midland Company, TVP, United States Patent and Trademark Office 81014793 (Decatur, Illinois, filed 19 October 1973, and issued 1 July 1975), https://tsdr.uspto.gov/#caseNumber=81014793&caseType=SERIAL_NO&searchType=statusSearch.

209 Ross Irwin, 'Dwayne Andreas's Bean Has a Heart of Gold', *Fortune*, October 1973, 138.

210 USDA ARS, 'Textured Vegetable Protein Products (B-1), FNS Notice 219', 1971, https://www.kn-eat.org/insite/Insite_Docs/IntheKnow/USDAMemos/FNSInstructions/FNS%20219.pdf.

211 General Mills Inc., Bontrae, 72459090 (MINNEAPOLIS MINNESOTA, filed 1 June 1973, and issued 26 March 1974).

212 Duane C. Wosje, 'TEXTURED VEGETABLE PROTEINS TO ALLEVIATE WORLD FOOD PROBLEMS', *Journal of Milk and Food Technology* 33, no. 9 (1 September 1970): 405, 407, https://doi.org/10.4315/0022-2747-33.12.405; cf. also Kenneth M. Wolford, 'Beef/Soy: Consumer Acceptance', *Journal of the American Oil Chemists' Society* 51, no. 1Part2 (January 1974): 131A-133A, https://doi.org/10.1007/BF02542111.

213 A cynic might note that the poor populations at risk of protein malnutrition were generally already accustomed to eating pulses, so new ways of making soybeans more palatable were most relevant for markets in the global north.

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impact.[214] A huge range of textured vegetable proteins are still produced for use in meat substitutes and as meat extenders; indeed, Archer Daniels Midland (now styled ADM) is still a major producer. But these products did not play a major role in food aid or efforts to address world food security.

The focus on protein and the story of the impending protein gap had cultural resonance beyond the politics of international development. One event of particular relevance for current debates about protein and sustainability was the publication of *Diet for a small planet* by Frances Moore Lappé in 1971.[215] This book—an international bestseller at the time whose influence remains important half a century later—was one of the first to make an environmental argument against eating meat. Lappé highlighted the land use inefficiency of animal agriculture as a means of producing calories and protein, arguing that contemporary world hunger and the protein gap created by expected population growth could be solved by shifting to vegetarian diets. In retrospect, it is this argument that represents the book's lasting contribution—but much of the text was focused on 'protein combining' and the supposed difficulty of getting enough protein with the right balance of amino acids without eating meat. In her later writing Lappé would note that the suggestion that it was possible to eat enough protein without eating meat seemed like "heresy" in 1971,[216] an observation that 19th century proponents of vegetarianism might have found familiar.

However, by the mid-1960s, new scientific findings had started to complicate the protein gap story: the best estimates of infant dietary protein requirements had come down. Where in 1936 the League of Nations had estimated that a one-year-old infant needed 3.5g of protein per 1kg of body weight per day for healthy growth, and Brock & Autret's report in 1952 had suggested a rate as high as 3.8g/kg/day, official FAO/WHO publications from 1965 onwards consistently estimated rates below 1.5g/kg/day[217] (see Figure 7). If the ratio of protein needed to calories needed was lower, this challenged the medical understanding of kwashiorkor: was it really caused by simple protein deficiency? Even if it was, the structural account of the problem was even harder to maintain. The argument of the 'protein gap' was that, from a population perspective, kwashiorkor was caused by an insufficient supply of protein even though enough calories were available. Lower protein requirements undermined this, implying that protein deficiency might be a consequence of general lack of food—if enough calories were supplied, enough protein would be also. At the same time, evidence was mounting that, in clinical practice, it was hard to distinguish kwashiorkor from other forms of malnutrition. In a population of children of the same age eating the same diet, some might show symptoms of kwashiorkor and some more general starvation (marasmus).[218]

214 Aaron Altschul, Special Assistant for International Nutrition Improvement to the Secretary of Agriculture, stated in 1968 that "[m]ost of these new foods will be available first to people who probably do not need them [...] but [...] the first thing to do with a new food is to establish it in the marketplace". Altschul, *Combating Malnutrition: New Strategies through Food Science, Remarks of Aaron M. Altschul, Special Assistant for International Nutrition Improvement to Secretary of Agriculture, to 2nd Joint Meeting of American Institute of Chemical Engineers and Institute de Ingenieros Quimicos de Puerto Rico*, Tampa, Fla., May 21, 1968, 13.

215 Frances Moore Lappé, *Diet for a Small Planet* (New York: Friends of the Earth / Ballantine Books, Inc., 1971).

216 Frances Moore Lappé, Anna Lappé, and Shastri Indo-Canadian Institute, *Hope's Edge: The next Diet for a Small Planet* (New Delhi: Viveka Foundation, 2005), 56.

217 For context, Millward & Jackson (2007) estimated that a one-year-infant required only 0.875g protein per kg of body weight per day.

218 J. C. Waterlow and P. R. Payne, 'The Protein Gap', *Nature* 258, no. 5531 (November 1975): 113, https://doi.org/10.1038/258113a0. This is not the place to go into the unsolved debate around the aetiology of kwashiorkor in detail. Protein deficiency remains a major possibility, with suggestive evidence from recent work on blood albumin levels, but the epidemiological evidence speaks against an association between dietary protein intake and developing kwashiorkor. A non-exhaustive list of other explanations put forward includes deficiency of the sulphur amino acids (perhaps in combination with high intake of cyanogens from cassava), exposure to aflatoxins (produced by the fungus *Aspergillus flavus*), changes in gut microbiota, and oxidative stress resulting from sequential infections in combination with low micronutrient intake. In contrast to the great attention kwashiorkor received during the 1960s and 70s, researchers now describe it as an 'orphan disease', subject to little medical or epidemiological research in spite of the fact that it still affects hundreds of thousands of people per year. André Briend, 'Kwashiorkor: Still an Enigma – the Search Must Go On', CMAM Forum Technical Brief (CMAM Forum, December 2014), 25 and passim, https://www.ennonline.net/attachments/2314/Kwashiorkor-still-an-enigma-CMAM-Forum-Dec-2014.pdf; Edem M. A. Tette and Juliana Yartey Enos, 'Letter to the Editor Aetiology of Kwashiorkor Then and Now–Still the Deposed Child?', *Asian Journal of Dietetics* 2, no. 1 (2020): 41–42; Malcolm G. Coulthard, 'Oedema in Kwashiorkor Is Caused by Hypoalbuminaemia', *Paediatrics and International Child Health* 35, no. 2 (13 May 2015): 83–89, https://doi.org/10.1179/2046905514Y.0000000154; Thi-Phuong-Thao Pham et al., 'Difference between Kwashiorkor and Marasmus: Comparative Meta-Analysis of Pathogenic Characteristics and Implications for Treatment', *Microbial Pathogenesis* 150 (January 2021): 104702, https://doi.org/10.1016/j.micpath.2020.104702.

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This initially led to little more than a change of terminology: where previously kwashiorkor and "protein malnutrition" had been identified as the problem, now the phrases "protein-calorie malnutrition" or "protein-energy malnutrition" were used. Yet the rhetoric and the policies remained broadly similar for some time,[219] with UN reports entitled "Feeding the Expanding World Population: Action to Avert the Impending Protein Crisis" (1967) and "The Protein Problem" (1968). As late as 1972, the UN General Assembly adopted a resolution stating that "protein-calorie malnutrition is the primary cause of high infant and child mortality, reaching from 25 to 30 per cent in many developing countries."[220]

But, just as with falling estimates of adult protein requirements in the run-up to the First World War, the gap between the scientific evidence and the general wisdom could not last forever—and just as before, when the consensus changed, it changed quickly. In 1974, Donald McLaren, a nutritionist who had worked with starving children in India, Tanzania, Lebanon and Jordon,[221] published an article in the Lancet under the provocative title "The Great Protein Fiasco".[222] In this he argued that the importance of protein as both problem and solution had been wildly overestimated for 20 years. It simply wasn't the case that all or most childhood malnutrition was kwashiorkor, or that kwashiorkor was straightforwardly protein deficiency; there was no longer any good reason to believe that there *was* a gap between protein production and demand above and beyond the gap between general food production and demand;[223] and projects to create innovative sources of protein had not and were never going to offer effective solutions to world hunger. The World Food Conference in November of that year focused on an ongoing famine in Bangladesh that had killed 1.5 million people: the Protein Advisory Group (at this point already renamed the Protein-Calorie Advisory Group) was not consulted for the conference and protein featured little in the proceedings.[224] One year later, in spite of strident criticism of McLaren,[225] a review article in Nature concluded that the concept of a worldwide protein gap was no longer viable.[226] Three years on, the Protein-Calorie Advisory Group was disbanded.

There had been voices speaking out against the focus on protein and kwashiorkor throughout these two decades. In McLaren's paper, Cicely Williams, the 'discoverer' of kwashiorkor as protein deficiency, is quoted: "For the last 20 years I've been spending my time trying to debunk kwashiorkor."[227] McLaren later called out other researchers whose work had pushed back against the consensus, including Indian statistician P. V. Sukhatme.[228] So why had the focus of international bodies including the WHO and FAO been so narrow?

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219 Cannon, 'Nutrition', S485.

220 UN General Assembly, 'Protein Resources [A/RES/2848]', in *Resolutions Adopted by the General Assembly during Its 26th Session, 21 September-22 December 1971*, 1972, 68–70.

221 Donald S. McLaren, 'To the Editor', Food and Nutrition Bulletin 20, no. 3 (January 1999): 369–70, https://doi.org/10.1177/156482659902000318.

222 Donald S. Mclaren, 'THE GREAT PROTEIN FIASCO', *The Lancet* 304, no. 7872 (July 1974): 93–96, https://doi.org/10.1016/S0140-6736(74)91649-3.

223 From 1974 on, attention began to be paid to notions of 'food security' (and later 'food sovereignty') that moved beyond a simplistic understanding of malnutrition as the individual consequence of societal under-production of food. These newer frameworks engaged with questions of food distribution, access, affordability, reliability and safety, cultural preferences, dietary balance, and the loci of political and economic control over the food system. In this more complex picture, it might not make any sense to try to 'diagnose' a problem with the food system by looking for an imbalance between the dietary needs of the world population and global food production: more than enough food can be produced, yet people can still go hungry. For more discussion of food security and food sovereignty, see Walter Fraanje, Samuel Lee-Gammage, and Tara Garnett, 'What Is Food Security?' (Food Climate Research Network, 12 March 2018), https://doi.org/10.56661/e49a6c96; Rachel Carlile, Matthew Kessler, and Tara Garnett, 'What Is Food Sovereignty?' (TABLE, 25 May 2021), https://doi.org/10.56661/f07b52cc.

224 Semba, 'The Rise and Fall of Protein Malnutrition in Global Health', 84.

225 Donald S. Mclaren, 'THE GREAT PROTEIN FIASCO', *The Lancet* 304, no. 7888 (November 1974): 1079, https://doi.org/10.1016/S0140-6736(74)92175-8.

226 Waterlow and Payne, 'The Protein Gap'.

227 Mclaren, 'THE GREAT PROTEIN FIASCO', July 1974, 93.

228 P. V. Sukhatme, 'Incidence of Protein Deficiency in Relation to Different Diets in India', *British Journal of Nutrition* 24, no. 2 (June 1970): 477–87, https://doi.org/10.1079/BJN19700047; Donald S McLaren, 'The Great Protein Fiasco Revisited', *Nutrition* 16, no. 6 (June 2000): 464–65, https://doi.org/10.1016/S0899-9007(00)00234-3.

Widespread protein deficiency had been an appealing diagnosis for the problem of world hunger. A more complex understanding of the situation, allowing very different stories in different places, would have required reliance more on subjective forms of evidence: appeals to personal experience, culture, context or politics. The protein gap and prevalent protein deficiency, by contrast, had the ring of objectivity: an explanation with scientific authority, backed by quantitative and experimental evidence, suited the cultures of science and government[229] and fitted well into an optimistic, technocratic approach to public health led by nutritional scientists.[230] Although no-one had designed it to be so, the profession of nutritional science was structured to favour single-nutrient explanations of problems, since individual scientists tended to be experts in a specific nutrient, and because such explanations were easier to explain to policy makers.[231] Kwashiorkor itself had the advantages of a visually striking presentation and of mostly affecting babies and children, the most sympathetic victims when building public support for aid. The structures of corporate and (inter)national power that impoverished half the world were manifold, and a diagnosis that made the problem of hunger solvable without the need to challenge them head-on could recruit the largest number of stakeholders in support. In retrospect this period was characterised by a huge waste of effort and money by the organisations trying to tackle world hunger, with systemic factors pulling the focus of many well-intentioned actors towards an explanation and solutions that were later revealed to be not just illusory but arguably counterproductive, since they distracted attention from the real causes of hunger and malnutrition.

At the same time, that it was again *protein* that had risen to the place of most important nutrient appears to be part of a longer-term historical pattern. Beliefs about protein, meat and race first developed in the 19th century had never really left the public imagination, even though scientific consensus had moved on—this made a scapegoat of the ignorance of poor black and brown mothers about the importance of protein in their children's diets. The assumption that child growth was the single best indicator of a healthy diet was methodologically defensible (it is a uniquely convenient, object measure), yet it was bound to put special emphasis on the dietary role of protein. Add to this the beliefs about cow's milk as the 'perfect food' that were current among nutritionists at the time and had been reinforced by successful nutritional policies during the Second World War, and the idea that the solution to world hunger was more protein seemed intuitively plausible. Institutions and infrastructures were then shaped by this understanding, creating a network of vested interests that sustained the same approaches long after the evidence had changed.

229 Willem Halffman, 'Frames: Beyond Facts versus Values', in *Environmental Expertise: Connecting Science, Policy and Society*, ed. Esther Turnhout, Willemijn Tuinstra, and Willem Halffman, 1st ed. (Cambridge University Press, 2019), 36–67, https://doi.org/10.1017/9781316162514.

230 Cannon, 'Nutrition'; Kimura, *Hidden Hunger*; Nelson, Nisbett, and Gillespie, 'Historicising Global Nutrition'.

231 Rivers, 'The Profession of Nutrition—an Historical Perspective'; Carpenter, 'The History of Enthusiasm for Protein'.

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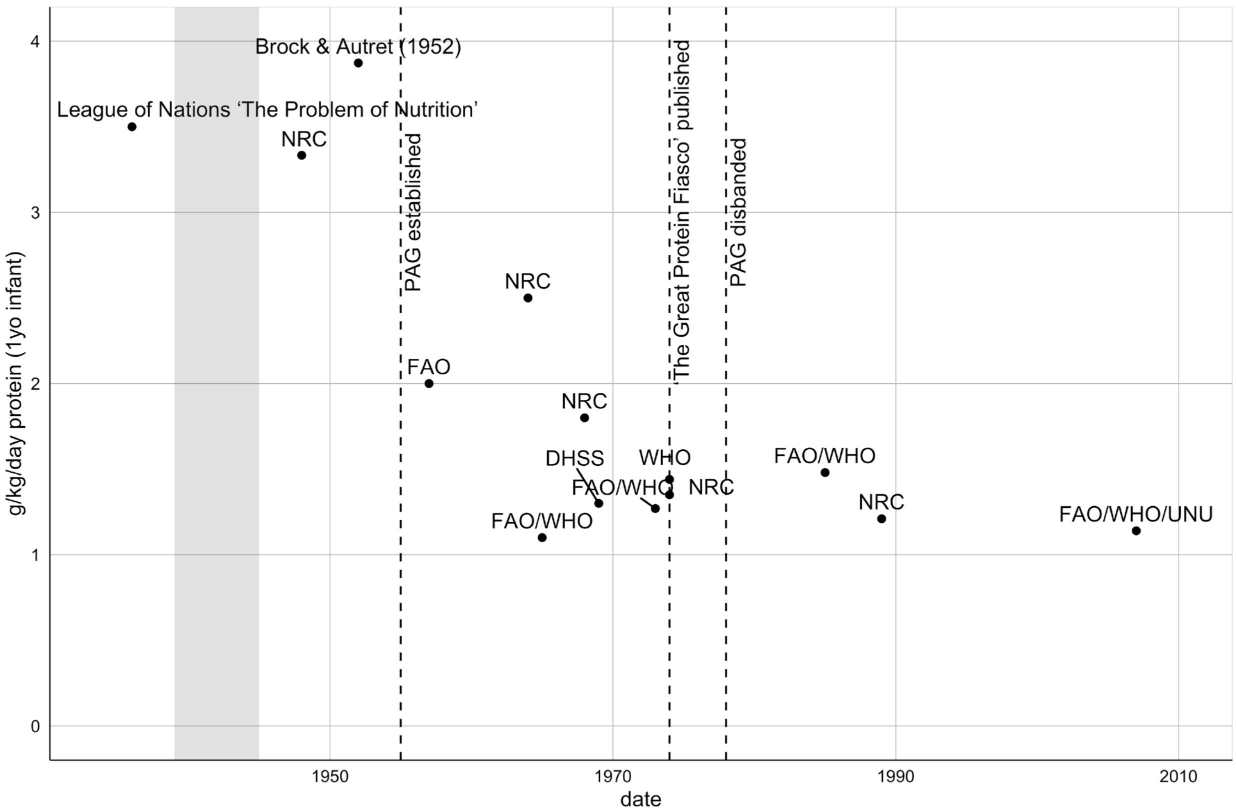

Figure 7: Recommendations for daily protein intake for 1yo infants by body weight by year; the shaded area shows the Second World War[232]

232 Technical Commission of the Health Committee, *The Problem of Nutrition*, II: Report on the Physiological Bases of Nutrition:15; Cannon, 'Nutrition', S485; Waterlow and Payne, 'The Protein Gap', 114; Passmore et al., *Handbook on Human Nutritional Requirements*, 20; Joint FAO/WHO/UNU Expert Consultation, 'Energy and Protein Requirements', 104–5; D Joe Millward and Alan A Jackson, 'Protein/Energy Ratios of Current Diets in Developed and Developing Countries Compared with a Safe Protein/Energy Ratio: Implications for Recommended Protein and Amino Acid Intakes', *Public Health Nutrition* 7, no. 3 (May 2004): 387–405, https://doi.org/10.1079/PHN2003545.

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6. Epilogue

"The dispassionate objectivity of scientists is a myth. No scientist is simply involved in the single-minded pursuit of truth, he is also engaged in the passionate pursuit of research grants and professional success. Nutritionists may wish to attack malnutrition, but they also wish to earn their living in ways they find congenial. Although many people are killed by malnutrition each year, an increasing number of us are kept alive by it."[233]

Where does the cultural power of protein come from? This paper has tried to answer this question by looking at history—especially the history of nutritional science, and certain episodes in that history in particular. This has led to one set of answers. Protein inherited its meanings from meat (associated with masculinity and strength) and from milk (associated with motherhood and nurturing)—in both cases foodstuffs that happened to form a larger part of the diets of colonisers than those of many colonised peoples. Conflicts around race and empire, national culture and tradition, added to the already great symbolic value of these foods. Nutritional scientists were as much products of their cultural contexts as anyone else, and these implicit beliefs about foodstuffs channelled their work towards conclusions about the nutrients that made those foodstuffs up. The shift towards nutritionist thinking, whereby nutrients usurped the place of foods in first scientific and then public discussion of diet,[234] facilitated this accrual of disparate meanings into protein.

This was not the only way this question could have been explored, and far from the only set of answers. Meat has deep symbolic significance in religions the world over, connecting it (and thereby connecting protein) to meanings around sacrifice, purity and impurity. There is a deep history of religious symbolism attached to milk, too, especially in the cultures of Europe, the Middle East and South Asia; rituals using milk, icons showing dairying, and religious textual references to milk are found in ancient Mesopotamian, Egyptian, Hebrew, Greek, Roman, and Norse sources, and in Jewish, Christian and Hindu texts.[235] [236] An association between meat and wealth and success is by no means unique to Western European cultures, and this links meat (and thereby protein) to celebration, generosity, cultural identity and pride. Animal agriculture shapes the landscapes with which many of us are intimately familiar, and so leads us to associate meat and dairy (and so protein) with pastoral beauty, nature, tradition. Beliefs about motherhood and milk, controversies around bottle feeding and infant formula played a bigger role than could be covered here, in the stories from Justus Liebig to Cicely Williams and the Protein Fiasco.[237]

The story of the 'discovery' of protein told here could also have been told as the construction of the macronutrients—the triumvirate of fat, carbohydrate and protein which emerged in part from Liebig's theories of biochemistry, as well as work by Carl Schmidt and earlier William Prout.[238] In the words of Michael Pollan,

233 Rivers, 'The Profession of Nutrition—an Historical Perspective', 229.

234 cf. Scrinis, *Nutritionism*.

235 Valenze, *Milk: A Local and Global History*, 13–33.

236 It is often impossible to separate out the symbolism of dairying and the consumption products derived from the milk of livestock from that of breastfeeding and human milk. For example, the Egyptian goddess Isis was a fertility goddess whose images showed her nursing an infant son, but also bovine goddess who wore a cow-horned headdress and whose husband was given libations of milk. These overlaps might be part of the reason that dairy foods are so easily endowed with cultural meaning: they are already adjacent to breastfeeding, brimming with associative links to mammalian birth, life, fertility and femininity.

237 For further discussion of the cultural history of milk, the reader is directed to several recent books: Valenze, *Milk: A Local and Global History*; Wiley, *Re-Imagining Milk*; Anne Mendelson, *Milk: The Surprising Story of Milk through the Ages: With 120 Adventurous Recipes That Explore the Riches of Our First Food*, 1st ed (New York: Alfred A. Knopf, 2008).

238 Scott-Smith, *On an Empty Stomach*, 35–36; Fu, 'Confronting the Cow'.

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"the history of modern nutritionism has been a history of macronutrients at war,"[239] and one frame in which to understand the waxing and waning of protein enthusiasm is through the tides of this war. The successive demonisation of fat and carbohydrate in the dieting culture of the last half century may have created a default valorisation of protein; in this frame, the current focus on protein might have as much to do with a decades-long cycle of interest in the other two macronutrients as it has to do with the cultural history of (high-)protein (foods).

Nevertheless, there are specifics in the stories told here with particular resonance and relevance for the modern day. In the current cultural enthusiasm for protein we can see a reverence for certain kinds of muscular bodies[240] reminiscent of discourses about meat, protein and strength in the late 19th century. In the explosion of new sources of protein and meat substitutes (plant-based burgers, cultured meat and milk, plans to "make protein from air"[241]) there are inescapable echoes of the techno-protein projects of the 1960s as well as the entrepreneurial scientists of the 19th century. Discussion of 'protein transitions' and the idea that increasing meat consumption in the developing world is an inevitability which will undermine our attempts to address global warming resemble mid-century fears about our ability to feed the growing world population. Over and again throughout this history, scientific theories and terminology have influenced society long after the evidence for them has changed.

These stories, then, not only tell us what factors feed our sense that protein is important, but contain a warning that it may be exaggerated. There is no denying that protein plays a crucial role in our lives. It is an essential nutrient, and changing the way we consume and produce protein may represent vital parts of the solution to the environmental crises of our age. Just as a 'charismatic nutrient' can draw a hyperbolic focus, the backlash when the fashion changes can cause us to miss new evidence about the old favourite: nutritional historian Richard Semba has argued that something like this happened with protein in the 1990s, allowing worrying new findings on protein malnutrition to escape the notice of policy makers.[242] Our goal must be to engage with these topics in a balanced way that enables us to respond to the full, complex picture of the evidence. In order to do this we must be cognisant of the power of protein—where that power comes from, and why we have bestowed it.

239 Pollan, *In Defense of Food*, 30.

240 For example, consider the prevalence of the #strongnotskinny hashtag in the fitspo movement, originally intended as a response to the pro-anorexia thinspo movement: the counter to the valorisation of undernutrition and resulting emaciation is the valorisation of exercise, high protein consumption and muscularity. Rayanne Connie Streeter, 'Are All Bodies Good Bodies?: Redefining Femininity Through Discourses of Health, Beauty, and Gender in Body Positivity' (Ph.D., Blacksburg, VA, Virginia Polytechnic Institute and State University, 2019), 34, https://vtechworks.lib.vt.edu/handle/10919/89894.

241 Alice Finney, 'Air Protein Creates Fake Steak from CO2 That Replicates Taste and Texture of Meat', *Dezeen*, 14 April 2022, https://www.dezeen.com/2022/04/14/air-protein-meat-alternative-recycled-carbon-dioxide/.

242 Semba, 'The Rise and Fall of Protein Malnutrition in Global Health'.

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