8. “Trois Empreintes d’un Même Cachet”: Toward a Historical Definition of Nutrition

A. R. RUIS

“There is no subject of more interest to the physiologist, of more practical importance to the physician, or that more urgently demands the grave consideration of the statesman,” wrote the English physician George Budd in 1842, “than the disorders resulting from defective nutriment.”[1] This assertion proved no mere hyperbole. Over the following century, concern about the pernicious effects of malnourishment only became more widespread, and the study of human nutrition expanded from a minor branch of physiological chemistry to a major domain of biomedical science. Yet as Budd’s claim implies, it is overly simplistic to understand human nutrition (or malnutrition) as merely a physiological process, however complex. Nutrition was less a rigorously defined scientific concept than a flexible semiotic device that provided intelligible and actionable explanations for many complex, elusive, or otherwise intractable problems of clinical medicine, public health, and political economy. “Medicine has recently and rapidly developed a keen nutrition consciousness,” wrote the American chemist Henry Sherman a century later. “It is finding in nutrition the solutions of many of its most baffling problems.”[2]

By the twentieth century, the concept of nutrition—and by extension, the discipline of nutrition—had become deeply entangled with a range of issues: agriculture, health, economics, defense, labor, education, and national identity, among others. Yet as scientists and physicians were extolling the importance of nutrition to just about everything, they increasingly struggled to articulate just what “nutrition” was. The American physician and nutrition expert George Palmer, for example, noted in 1930 that nutrition “is an ambiguous term. It awaits a specific definition.”[3] It is, by and large, still waiting.

Since the early nineteenth century, scientists and health experts have continuously refined and renegotiated the meaning of nutrition, a construct which became ever more important but also ever more amorphous.[4] For many nutrition experts, this expansiveness simply made the term an empty vessel into which anything could be poured. “The word nutrition covers a multitude of sins, gross exaggerations, and misconceptions,” wrote the American physician George Dow Scott in 1942. “Its interpretation is quite at odds among varying groups of peoples, and misconceptions, ignorance, the pseudo sciences, tribal, racial, and religious conceptions, all enter into its meaning.”[5] Yet others argued for a necessarily broad perspective, as a definition restricted to biochemical or physiological aspects omitted key ways in which nutrition represented a complex set of interactions between an organism and its environment. In this view, as the British nutritionist Christine Rossington put it in 1981, nutrition was best defined as “the outcome of interplay between, and integration of, two dynamic ecological systems, the human internal bio-physical environment, and the external physical, economic and socio-cultural settings in which man lives.”[6]

The conceptual plasticity of nutrition was by no means unique among scientific concepts, but it was remarkably broad and enduring. It seemed to many that there was no science unutilized in the exploration of nutritional function, no state of health or disease in which nutrition did not play a contributive or ameliorative role, and no grave social or political matter in which the nutrition of the population was not implicated. “The science of nutrition . . . utilizes the combined knowledge of all fundamental and applied sciences,” wrote the nutritionists Kirsten Toverud, Genevieve Stearns, and Icie Macy in a report prepared for the U.S. National Research Council in 1950. “Even sciences such as theology, philosophy, and psychology are intimately involved in nutrition, owing to their involvement in psychosomatic relationships in the body. . . . Nutrition has been approached from many directions—the bioenergetic, the anatomical, the statistical, the social, and the mental points of view, in addition to those of the physician, biologist, and chemist."[7] Indeed, this fluidity only made nutrition a more powerful concept, as it could be readily adapted to a wide range of contexts, problems, and agendas.

Yet this very fluidity vexed many nutritionists, who regarded it as a lack of intellectual rigor with real-world consequences. The meaning of medico-scientific concepts like nutrition was continually debated and refined in part because definitions matter beyond the realm of theory or semantics. Policy, research, product development, and regulation—and allocations of money and resources in each of those areas—are influenced significantly by fundamental understandings of core concepts and how they are organized. There is a rich literature on the ways in which definition and classification shape, or even engender, the most fundamental features of social action and interaction, and on how such discursive practices can be analyzed and modeled to understand the underlying culture that produced them.[8] In this paper, I argue that conceptual models of a discourse can be abstracted from textual or other evidence as networks of relations among constructs, and that these models can help identify larger patterns in the evolution of such discourses over time.[9] Nutrition, a heavily contested concept imbued with a wide range of meanings across numerous domains, provides a particularly useful case for exploring the affordances of this approach.

This aim arises from two related challenges that historians increasingly face. First, the volume of historical data is large and continuing to grow, and the sheer quantity of available sources—what William Turkel terms the "infinite archive" of digital materials—cannot be processed using traditional methods alone.[10] Second, traditional methods of historical research are typically based on deep and often solitary human engagement with the relevant materials, an optimal approach for microhistorical analysis. But historians who want or need to engage with macrohistorical questions require a different methodological toolkit, and, in many cases, an entirely different perspective on the research process. In other words, there are important historical questions that cannot be answered solely through close readings of texts.[11]

Of course, good macrohistorical work typically requires considerable microhistorical sophistication. It is facile to assume that more or more accurate data will automatically lead to better understanding, or that broad patterns can be understood without close attention to the underlying source material. The view that computers can take massive amounts of information and do most of our analytic thinking for us, a belief embraced by many data miners and glorified by tech evangelists, more often than not yields statistically significant but conceptually meaningless results. We can and should outsource *some* of our thinking to smart machines, much as we have outsourced some of our memory to books and other media for thousands of years. But to do this well is to understand the limitations and leverage the affordances of different approaches to processing and analyzing information, both human and machine. The practice of historical research stands to benefit considerably from, and may even require, a mixed-methods approach that combines the qualitative and the quantitative and incorporates the analytic strengths of human interpretation and computational processing.

In what follows, I attempt to model the concept of "nutrition" in English-language sources from the nineteenth and twentieth centuries using *epistemic network analysis* (ENA), a set of techniques for measuring, visualizing, and comparing patterns of association among conceptual elements.[12] In doing so, I argue that conceptual networks can help us understand macrohistorical patterns in discourses—in this case, discourses of nutrition—without sacrificing microhistorical rigor. Specifically, I will describe an approach in which microhistorical analyses inform the development of macrohistorical models that in turn suggest new avenues for microhistorical investigation.

Conceptual Networks

Definition, and the taxonomic practices that attend efforts to delineate knowledge, is the subject of considerable research in the history and philosophy of medicine and biomedical science.[13] Critically, definitions of concepts are rarely simple, stable, or uncontested. How something is defined—and who has the power to define it—often has significant and far-reaching consequences. For example, what counts as a "true" food allergy, or where the line is drawn that distinguishes the obese from the merely overweight, affects everything from patient care and research funding allocations to politics and everyday social interactions. Yet it can be challenging to characterize how complex concepts are defined, especially when the goal is to understand how those definitions change across contexts or over long periods of time.

Conceptual complexity stems in part from the relationship between concepts and the language used to denote them. The French chemist Antoine Lavoisier argued that science consists of three things: the series of facts that constitute the science, the ideas that represent those facts, and the words that express those ideas. The word, he argued, should awaken the idea, and the idea portray the fact, like three impressions of the same seal. It is thus impossible, according to Lavoisier, to separate language from science.[14] In other words, *concepts* (facts) are ultimately represented by *tokens* (words and other symbols). But where tokens are generally static, varying relatively little over time, concepts are both abstract and dynamic; what grounds them in some context is a complex set of interactions among other concepts, and that set of interactions—that *conceptual network* (idea)—is what links a token and a concept. Put another way, as the anthropologist Terrence

Deacon explained, “the pairing between a symbol (like a word) and some object or event is . . . some complex function of the relationship that the symbol has to other symbols.”[15]

Importantly, concepts are not immutable, like Platonic forms, but evolve along with the ways of thinking in which they are embedded. Medico-scientific concepts are part of the grammar of some *community of practice*, what Ludwik Fleck termed a “thought collective” (*Denkkollectiv*): “a community of persons mutually exchanging ideas or maintaining intellectual interaction.”[16] Through these interactions, a thought collective develops a particular “thought style” (*Denkstil*), a system and set of rules for knowledge production and organization in that culture—that is, a *discourse*. The result, Fleck argued, is that concepts have no abstract meaning; they have meaning only insofar as they are embedded in some thought style, which is, in turn, associated with some thought collective. “The statement, ‘Schaudinn discerned *Spirochaeta pallida* as the causative agent of syphilis,’ is equivocal as it stands,” Fleck reasoned, “because ‘syphilis as such’ does not exist. There was only the then-current concept on the basis of which Schaudinn’s contribution occurred, an event that only developed this concept further. Torn from this context, ‘syphilis’ has no specific meaning.”[17]

Concepts cannot be abstracted from their context in part because they are deeply interconnected with other concepts within the discourse of some community of practice. Disease, for example, is not simply a pathophysiological process; as Charles Rosenberg has argued, it is “a biological event, a generation-specific repertoire of verbal constructs reflecting medicine’s intellectual and institutional history, an aspect of and potential legitimation for public policy, a potentially defining element of social role, a sanction for cultural norms, and a structuring element in doctor/patient interactions.”[18] To understand disease as a concept is thus to understand the interrelations among all these dimensions—in other words, to see it as a complex network of associations among biological, interpersonal, social, cultural, political, institutional, and historical factors, all of which are grounded in particular discourses and communities and in particular times and places.

Yet in arguing that concepts cannot be abstracted from their context, I am not suggesting that concepts cannot be abstracted at all. In his work on abolitionist arguments in nineteenth-century newspapers, for instance, Timothy Shortell argues that "the sociocognitive structure of a discourse" can be modeled "as a networked field of concepts from which arguments are fashioned."[19] That is, conceptual networks, appropriately contextualized, can provide a means not only for characterizing the structure of a discourse but also for making comparisons across discourses and over time. In what follows, I explore ways to understand changes in nutrition as a concept over the nineteenth and twentieth centuries.

Nutrition as Word, Idea, and Fact

There are a number of powerful tools available for analyzing language usage, such as changes in word frequencies over time. Google's *Ngram Viewer*, for example, can plot the relative frequency of some *ngram*, a particular string of continuous characters such as a word or phrase, over time.[20] Figure 8.2 shows the *Ngram* graph for the word "nutrition," broken out by case, from 1800 to 2000 in the English language corpus (i.e., English-language books digitized by Google Books). The graph represents, for each year, the relative proportion of all one-grams that were "nutrition" or "Nutrition." As figure 8.1 shows, use of the term was relatively rare until about 1840. Between 1840 and 1870, usage more than doubled. While the fluctuation in relative usage was greater over the twentieth century, the overall trend remained one of increasing frequency. Interestingly, "Nutrition" (with a capital N) was very uncommon until the twentieth century. Starting around 1930, its relative frequency has almost the same pattern as that for "nutrition" (with a lowercase *n*). Because the most likely reason for capitalization in English is if a term appears as the first word in a sentence—which, when that word is a noun, generally indicates that it is the subject of the sentence—this suggests that "nutrition" became commonly used as an abstract noun only after the turn of the twentieth century.

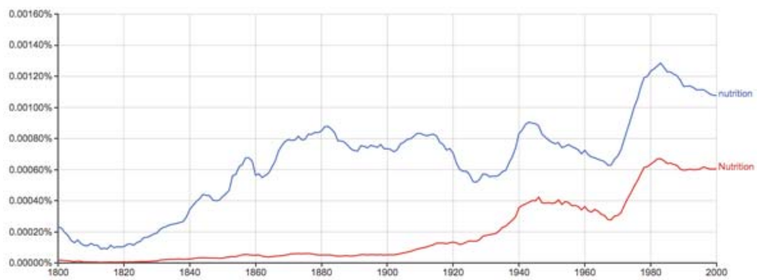

Figure 8.1: Google Ngram graph showing the frequency of the terms "nutrition" and "Nutrition" in the Google Books English language corpus from 1800–2000[21]

Analysis of usage in academic journals shows a similar pattern. The graph in figure 8.2 plots the number of articles in the JSTOR database containing the word "nutrition" or "Nutrition" from 1800 to 2000. As in the Google Books data, use of the term is rare until 1840. While the JSTOR data show what appears to be a steeper increase during the twentieth century, note that figure 8.2 depicts raw data, which haven't been normalized (e.g., to account for overall increases in the number of academic articles published). Nonetheless, it is clear that usage of the term "nutrition" in academic work increased significantly after about 1930.

While these analyses are helpful for understanding changes in word usage and identifying key points in time for more focused investigation, they do not give any indication of what people *meant* when they used the term "nutrition." That is, they are lexical rather than semantic analyses. In the case of nutrition, as noted above, the gap between the two types of analysis is particularly broad, as the term was used in remarkably diverse and, at times, mutually inconsistent ways.

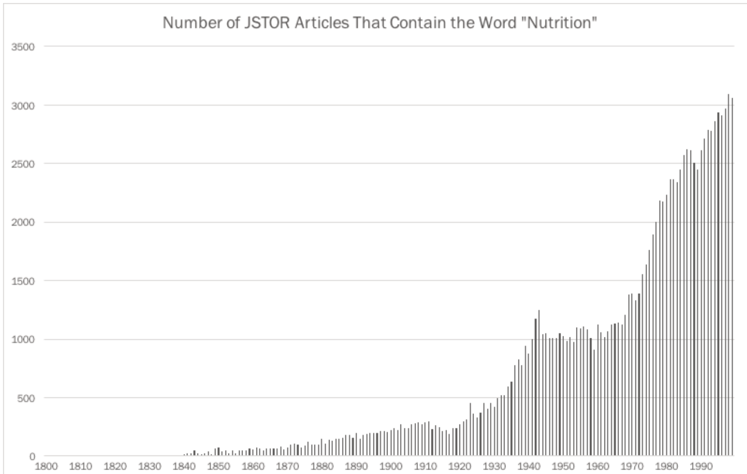

Figure 8.2: Total number of articles in the JSTOR database published between 1800 and 1999 that contain the word "nutrition" or "Nutrition" (data obtained in January 2018)

Many scientists and physicians in the nineteenth century described nutrition in almost poetic terms. The eminent physiologist Claude Bernard defined nutrition as "organic creation": "La nutrition et le développement ne sont rien autre chose . . . qu'une *création* organique."[22] Referencing Aristotle's designation of the nutritive soul (θρεπτική ψυχή) as the foundation of all life, such definitions located nutrition among the most basic processes that distinguish living organisms from inert matter.[23] Nutrition was, according to various experts, "the cardinal function of organic life,"[24] or "the great function by which life is sustained—in fact, it is life itself."[25] Yet when it came to defining nutrition in more concrete terms, most nutrition experts in the early to mid nineteenth century regarded nutrition as a specific physiological process through which food is ingested, digested, absorbed, and assimilated into the body. "Nutrition may be considered the completion of assimilating functions," wrote one physiologist in the first decade of the nineteenth century. "The food, changed by a series of decompositions, animalized and rendered similar to the being which it is designed to nourish, applies itself to those organs, the loss of which it is to supply, and this identification of nutritive matter to our organs constitutes nutrition."[26]

By the turn of the twentieth century, professional definitions of nutrition were starting to become more holistic, reflecting the expansion of nutrition beyond the domain of physiological chemistry. The evolution of the concept into an abstract noun was one marker of this change, as nutrition came to encompass not only the "assimilating functions" but also their end result: the state of health arising from nutritional processes. Nutrition was particularly embraced by pediatricians, both as part of the emerging practices associated with well-child care and as a powerful explanatory element of pathography.[27] "Pediatrics," the German physiologist Franz Knoop wrote in 1913, "has become largely a study of the chemical pathology of nutrition."[28] This broadened use of nutrition led to broader definitions. In the 1921 article "What Do We Mean by Nutrition?" American pediatrician Ira Wile wrote: "One recognizes that in the consideration of nutrition there are involved problems of activity and rest, digestion, mental attitudes, moral entanglements, as well as over-feeding, under-feeding, and unsuitable feeding, inadequate digestive organs or disorders that may affect digestion or assimilation but are dependent upon underlying pathological states such as tuberculosis or syphilis."[29] For pediatricians and public health workers, considering nutrition in the strictly biochemical sense was unhelpful. Whether assessing children's growth and development, diagnosing and treating illnesses, or developing community-based interventions, nutrition had to be considered in a broader socio-medical context. "While there may be normal nutrition without health," wrote the eminent pediatrician L. Emmett Holt, "there cannot be health without normal nutrition."[30]

Pediatricians and dietitians in particular, and health professionals more generally, thus took an ever broader view of nutrition in attempts to understand the role of nutrition in health and disease. Nutrition scientists, too, began to look beyond the organism to understand nutrition, increasingly seeing it in ecological rather than strictly physiological terms. For example, when *Nutrition Today* published an essay in 1968 by the eminent diabetes researcher Harold Himsworth entitled, "What 'Nutrition' Really Means," it sparked a debate about what the study of nutrition encompassed. Himsworth defined nutrition simply as "the analysis of the effect of food on the living organism." For Himsworth, this wasn't merely an issue of definition, but of professional identity. "As long as nutrition holds firm to that as its *raison d'être*," he argued, "its continued identity is assured. . . . Let it once lose sight of this, however, and then it will lapse back into its component subjects."[31] In the subsequent issue, Ancel Keys wrote in support of this simple statement, but several other nutrition experts took issue with its restricted perspective. D. Mark Hegsted, for example, found it "much too narrow," arguing instead that "nutritionists must be concerned with the entire process" by which food is ingested and utilized. "This means," he argued, "concern about things such as agricultural policy and what foods are produced; processing which may enhance or detract from food's nutritional value and make it more or less acceptable to the consumer; the distribution process which determines food availability to the consumer; and cultural, educational, and financial factors which determine what is actually chosen and eaten."[32]

This expansion of nutrition as a concept in Europe and the United States was due not simply to changes in medical and public health practice, but rather reflects larger changes in state concern about food and health. By the early twentieth century, the once perennial challenge of sufficient production and efficient distribution of foods became increasingly solvable due to improvements in agriculture, surplus management, food processing and preservation, and distribution. With these improvements came a gradual lessening of concern about widespread hunger and a commensurate increase in concern about widespread malnourishment. Consequently, governments began to focus more and more on the complex questions of how best to ensure diets that were optimal not only in food quantity but also in nutritive quality. At the same time, the tailoring of diets to maintain and restore health in individuals, a central element of medical practice from antiquity, gradually accommodated dietary theories based on universal human requirements for various chemical substances. As scientists increasingly specified human food needs in quantitative terms, nutrition, once a predominantly individual concern, became a population-level issue. Thus, both biomedical research on nutrition and individual self-management of diets became issues of political economy.[33]

Yet, as definitions shifted from the more narrowly physiological to the more expansively ecological, ontological uncertainty remained relatively high. “There is so much ignorance of the fundamental facts which lie behind the science of nutrition,” wrote the Scottish physician and physiologist E. P. Cathcart in 1928, “if one can venture to call nutrition a science when so much yet remains obscure.”[34] This sense that nutrition was less a body of defined knowledge than a black box with a wide range of functions remained common throughout the twentieth century. “Nutrition science,” as the nutritionist Jean Mayer put it in 1986, “is not a discipline, it is an agenda.”[35]

A key part of understanding professional discourses on nutrition, then, is understanding how nutritionists and other nutrition experts thought about nutrition as a core concept in their work. However, it is difficult to identify broader trends across long spans of time solely through close readings of texts. Even when it is possible to understand some of the broader macrohistorical trends from a careful microhistorical analysis, it can be helpful to test those theories using a different method, triangulating understanding across modes of knowing. In what follows, I describe a process for modeling the development of nutrition as a concept and present preliminary results that provide a macrohistorical perspective on professional nutrition discourse over two centuries.

Modeling Nutrition as a Conceptual Network

Data Collection

To build a dataset of nutrition definitions published in or translated into English in the medico-scientific professional literature between 1800 and 2000, I searched (a) full-text databases for journal articles, books, reports, and reference materials written on the topic of nutrition by scientists, physicians, and other health professionals, as well as (b) physical copies of books, reports, and reference materials on food and nutrition or on topics likely to contain discussions of nutrition, including physiology, dietetics, medicine, and public health.[36] Works on animal nutrition (or physiology, etc.) were included as long as "animal" was used as a category that incorporates humans; thus, works on veterinary nutrition were excluded. Different editions of the same book or reference work were included.

What counts as a "definition" is, of course, a matter of interpretation; while many writers were explicit in their definitional goals, it was necessary in other cases to determine whether a given discussion of nutrition represented an attempt at definition. To make this determination in ambiguous cases, context and professional judgment were used. Only definitions of nutrition without qualifications were included. Thus, definitions of "good nutrition," "cellular nutrition," and so on were excluded on the grounds that these concepts were explicitly defined as some part or subset of nutrition more generally.

The dataset used in the present analysis contains 226 definitions of nutrition. Figure 8.3 shows the number of definitions from each decade.

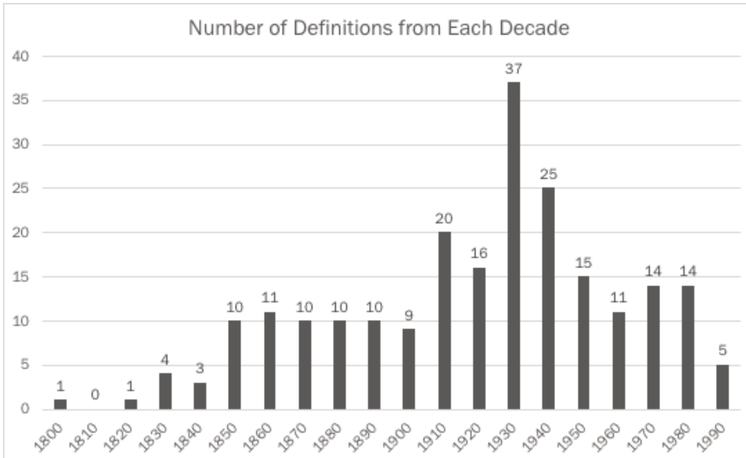

Figure 8.3: Histogram showing the number of definitions from each decade included in the dataset

Importantly, the data collection for this project is an ongoing process, and so this sample is perhaps more haphazard than many historical datasets. In particular, materials that have been digitized and are full-text searchable are over-represented in the dataset, as are physical materials that are easily accessed. The 1930s are also somewhat over-represented as well, though that may be due to an actual uptick in publishing on nutrition, as discussed above; beginning in the 1920s, the discovery of vitamins and other micronutrients and the subsequent construction of the "newer knowledge of nutrition" marked a significant expansion in and alteration of nutrition discourse.[37] All that being said, the dataset is sufficiently representative to warrant analysis, though results should be considered suggestive rather than definitive due to the possibility of significant sampling bias.

Coding

There are many ways to create network models of qualitative data. Perhaps the simplest (conceptually) is to construct a lexical network of connections among the key words and phrases in the dataset.[38] In this case, for example, one could create a network where each node is a unique word or phrase, and the connections among the nodes are defined by whether or not any two words or phrases appear in the same definition of nutrition. These unique connections could then be summed over some period of time to produce a weighted lexical network model of the definition of nutrition in that period, where the thickness of each line would correspond to the frequency with which the two connected words co-occurred.

Figure 8.4, which shows a simplified example of this kind of network, represents connections from nutrition to other key words and phrases in four definitions published during the 1830s.[39] Thicker lines indicate connections that occurred in more than one definition, with the thickness proportional to the number of definitions in which the two terms co-occurred.

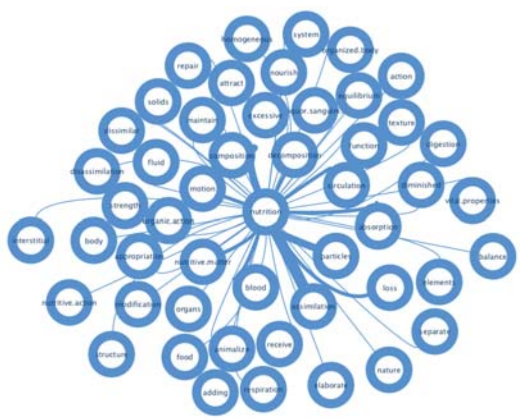

Figure 8.4: Network diagram showing connections between "nutrition" and other key words or phrases in four definitions of nutrition published during the 1830s

On one hand, this network provides some useful information about how nutrition was defined in the 1830s. We can see that assimilation was a key concept, and the only one to appear in all four definitions. Other key concepts include composition and decomposition, absorption, circulation, and particles, but there are a large number of technical terms that occurred in only one of the four definitions. As a whole, the network indicates that the definitions privilege the physiological, and many of the terms denote actions or processes.

On the other hand, this approach has a number of limitations. If the number of definitions being modeled were larger, the visualization would quickly become nearly impossible to interpret; this would be true even in this very small model if connections among all the terms were included, which may be needed. For example, one might want to know not only the extent to which "nutrition" and "assimilation" are connected, but also the extent to which "assimilation" is connected to other key words or phrases in definitions of nutrition. While there are many sophisticated statistical techniques that could be used to obtain this kind of information from networks too complex to visualize, the network model would quickly become challenging to interpret. This is compounded further if we want to compare the networks of nutrition definitions from different contexts or different points in time. But perhaps most importantly, this network was constructed simply based on the presence or absence of words—that is, it is not based on any interpretation of the definitions. Thus the only way to make meaning is by interpreting the network model itself, but the words in the model have all been abstracted from their context, making that difficult. For example, what are "particles" in this case? Does the term mean the same thing in each of the three definitions in which it occurred? And so on.

One way to overcome these challenges is to construct a network model not with the raw data but with coded data. Within the discourse of some culture, *codes* are symbols or concepts that have meaningful interpretations.[40] Thus, a researcher familiar with a given context can interpret the discourse in terms of codes. For example, Glesne describes coding as "a progressive process of sorting and defining and defining and sorting those scraps of collected data (i.e., observation notes, interview transcripts, memos, documents, and notes from relevant literature) that are applicable to our research purpose. By putting like-minded pieces together into data clumps, we create an organizational framework."[41] In other words, while coding is a deliberate process of simplification, it is one based on interpretation, providing a method for condensing the messiness of the raw data into a discrete set of key elements that can be quantified to identify larger patterns, patterns which may not be apparent based only on close reading of the materials. In building a network model of the coded rather than the raw text data, the model is based on an interpretation of the texts, not simply on some explicit attribute of them, and thus the larger patterns identified are more likely to be meaningful.

To construct network models using this approach, each definition in the dataset was coded for 14 elements commonly related to concepts of nutrition.[42] The codes, which are summarized in table 8.1, fall into three main categories: (1) *physiological* elements are the internal mechanisms by which foods are processed and used in the body; (2) *adaptive* elements are individual actions or conditions that are related to nutritional processes or outcomes; and (3) *ecological* elements are systemic or structural elements that are related to nutritional processes or outcomes. Thus for each definition in the dataset, there is corresponding information that indicates whether each code is present or absent; that is, each definition is interpreted and categorized according to these concepts.

This raises, however, a key challenge for understanding conceptual change over time, and in particular over long periods of time. As concepts change—that is, as the structure of associations that characterizes a concept in some context changes—so do all of the related concepts in that culture. For example, part of understanding the discourse on nutrition may involve understanding the concept "food" and how it is related to "health." Yet while the concept of "food" in one context was something like aliment or nutritive matter which can be ingested and assimilated into an organism, "food" in another context was also a substance composed of one of more chemical constituents: fats, carbohydrates, proteins, vitamins, minerals, and water. To address this issue, all codes included in the analysis were applicable across the full time period. The tradeoff in taking this approach, of course, is that each code represents a relatively broad concept.

Table 8.1: Coding scheme used in epistemic network analyses

	Code	Definition	Example
Physiological	Assimilation	The process of making food or nutrients part of the self	"that function by which the nutritive matter already elaborated by the various organic actions, loses its own nature and assumes that of the different living tissues"
	Excretion	The elimination of waste products that arise from the bodily processing of ingested food	"the relative balance and co-ordination of the functions of digestion, absorption, and assimilation of food as well as the excretion or waste products"
	Maintenance	The process of sustaining bodily processes, including generating heat; the process of repairing damage, waste, or loss	"to rebuild body substance and to create heat"
	Energetics	The provision of energy for physiological processes or work	"process by which food is...utilized for body energy"
	Growth	Growth or development of cells, tissues, or the whole organism	"the conversion of the nutrient matter into living matter, ...which may increase that which has been already produced (growth of formed material)"

Table 8.1 *(continued)*

Adaptive	Food & Diet	Aliment, or any of its constitutive elements (e.g. nutrients); diet or consumption habits or patterns at the individual or population level	"food has been defined as a well-tasting mixture of materials, which, when taken in proper quantity into the stomach, is capable of maintaining the body in any desired state"
	Behavior	Mental, emotional, or behavioral processes or states	"the term 'nutrition' should be retained for a wide conception of the state of well-being which characterizes the individual who is both physically and psychically sound"
	Activity	Physical activity, exercise, or work, or consideration of strength, stamina, or vigor	"external work of the body"
	Sleep	Sleep, rest, or fatigue	"body and mental rest"
	Health & Disease	State of health or illness, or reference to specific aspects of health, hygiene, illness, or disease	"bringing about better health and…prolonging life"
Ecological	Environment	One's physical context or surrounding, whether natural or built	"nutritional needs of body tissues vary with such things as climate"
	Economics	Economic aspects of nutrition, financial factors, or socio-economic status	"financial factors which determine what is actually chosen and eaten"
	Education	One's understanding of nutrition or educational processes for teaching or learning about nutrition	"proper education, technical expertise, and the use of resources in applied nutrition and food technology"
	Food System	The production, processing, and distribution of food	"food production and food supplies, including processing, preservation and preparation"

Epistemic Network Analysis

There are a number of publications that describe in detail the method with which ENA constructs network models,[43] but in brief, ENA creates for each unit a table (adjacency matrix) that quantifies the co-occurrence of coded elements for all lines in the dataset associated with that unit. In this case, each unit is a unique source (i.e., a book, article, reference work, or report); though most sources contain only one definition of nutrition, some contain multiple definitions, and each unique definition was entered on its own line in the dataset. In cases where definitions extend to multiple paragraphs, each paragraph is entered on its own line. This was done so that co-occurrences that were present in multiple definitions from the same source or in multiple paragraphs within the same definition would be modeled as stronger connections.

The resulting co-occurrence matrices were normalized (to model relative rather than absolute differences in connection strength) and embedded in a high-dimensional space, where each dimension represents a unique co-occurrence of codes. To create an ENA model, a dimensional reduction is performed (in this case, a singular value decomposition, or SVD), and the nodes of the network model—the coded elements—are placed in a metric space formed by the reduced dimensions using an optimization algorithm, such that the centroid of each network corresponds to the location of the network in the dimensional reduction. The result is two coordinated representations: (1) the location of each network in a *projected metric space*, in which all units included in the model are located, and (2) a *weighted network graph* for each network, which explains why the network is positioned where it is. An ENA model thus enables comparison of networks both visually and statistically, and every connection in the model is linked to the coded data that the connection represents, facilitating qualitative validation of the quantitative model.

Results

To examine how the discourse of nutrition changed over the nineteenth and twentieth centuries, I constructed an ENA network model containing a network for each unique source in the dataset, and computed mean networks for four time periods. The divisions between periods reflect points in time when changes in nutrition discourse appeared to be relatively stark based on quantitative (Google *nGram* and JSTOR) and qualitative analysis of the nutrition literature. Figure 8.5 shows the mean ENA network for each of the

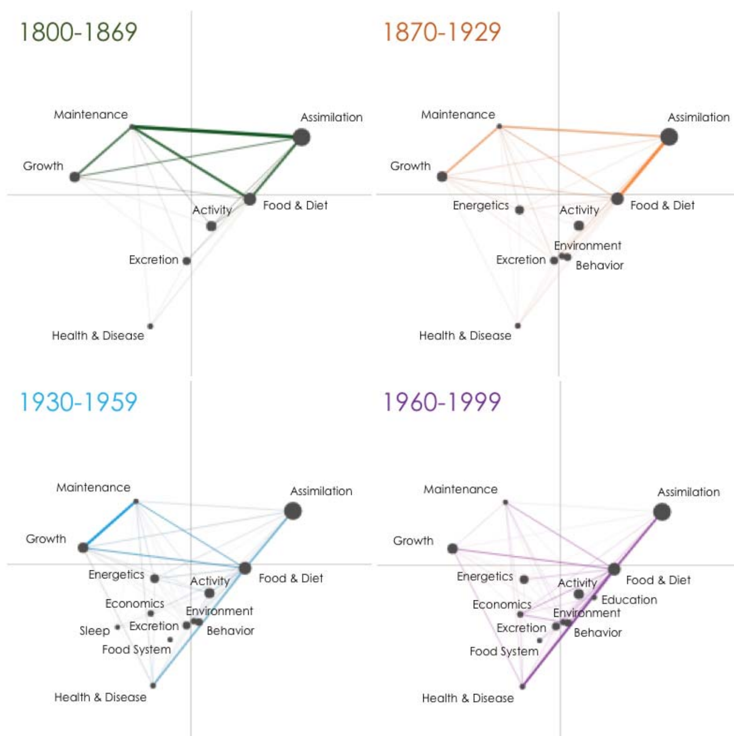

Figure 8.5: Mean ENA networks of nutrition definitions from four time periods

four time periods. Thicker, more saturated edges indicate stronger connections. The mean networks show a general evolution in the definition of nutrition from a largely physiological concept (1800–1869) to one that includes both physiological and adaptive elements (1870–1929), and ultimately one that is more holistic, balancing physiological, adaptive, and ecological elements (1930–1999). Note, too, that issues of health and disease continued to become more important over time, particularly as they relate to food and diet.

Figure 8.6 shows the mean network locations of each time period, along with the 95% confidence intervals (the individual network locations are omitted for legibility). The location of a network or

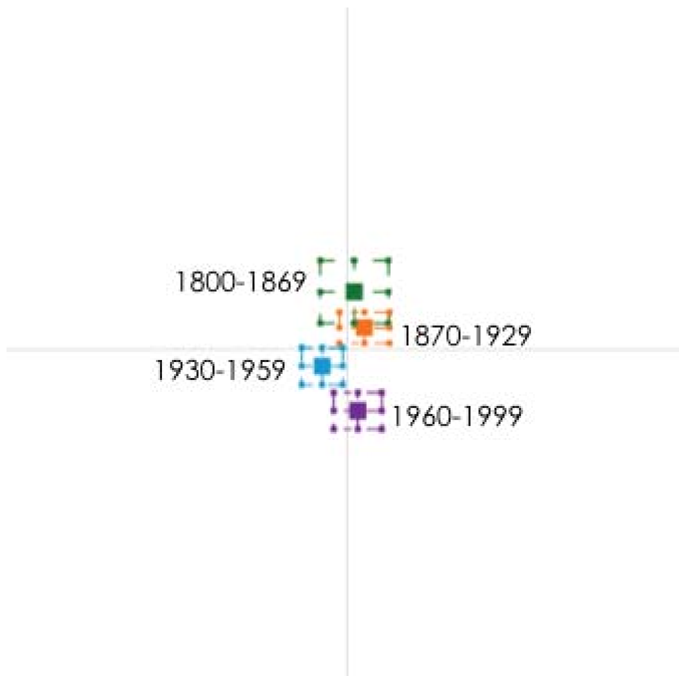

Figure 8.6: Mean ENA network locations of nutrition definitions from four time periods, with the corresponding 95% confidence intervals

mean network in ENA space indicates which connections were strongest in the network. Thus, a network that appears in the upper part of the space (i.e., a network with a high *y*-value) has stronger connections among the physiological elements, while a network that appears in the lower part of the space (i.e., a network with a low *y*-value) has stronger connections among the adaptive or ecological elements. Because the networks are all projected into a metric space, it is possible to compute descriptive statistics and conduct null hypothesis significance tests (see table 8.2). All means are statistically significantly different on the second (*y*) dimension ($p < 0.05$) with medium effect sizes ($r \approx 0.30$).[44]

Table 8.2: Statistical measures of the differences between mean networks on the second (y) dimension. All differences are statistically significant (p < 0.05) with medium effect sizes (r ≈ 0.30)

	Mann-Whitney U	***p***	***r***
1800–1869 vs. 1870–1929	816	0.03*	0.27
1870–1929 vs. 1930–1959	1846	< 0.01*	0.32
1930–1959 vs. 1960–1999	779	0.01*	0.32

Once an ENA model has been constructed, it can be used to explore other phenomena of interest. In this case, for example, networks can be constructed by type of source across the whole time period. As figure 8.7 shows, each type of source tends to favor a different kind of definition. Unsurprisingly, reference works, which tend to have the shortest definitions of nutrition, focus primarily on the physiological elements. But monographs also differ from articles and book chapters, with the latter containing more holistic definitions. This may be because monographs, many of which are textbooks or works designed for broader audiences, are more likely to represent consensus within a field. In contrast, articles and book chapters are more likely to present novel, preliminary, or contrary thinking on a topic, and, perhaps most importantly, they are more likely to be directed at other professionals in the same field rather than learners within those fields or adjacent professionals.

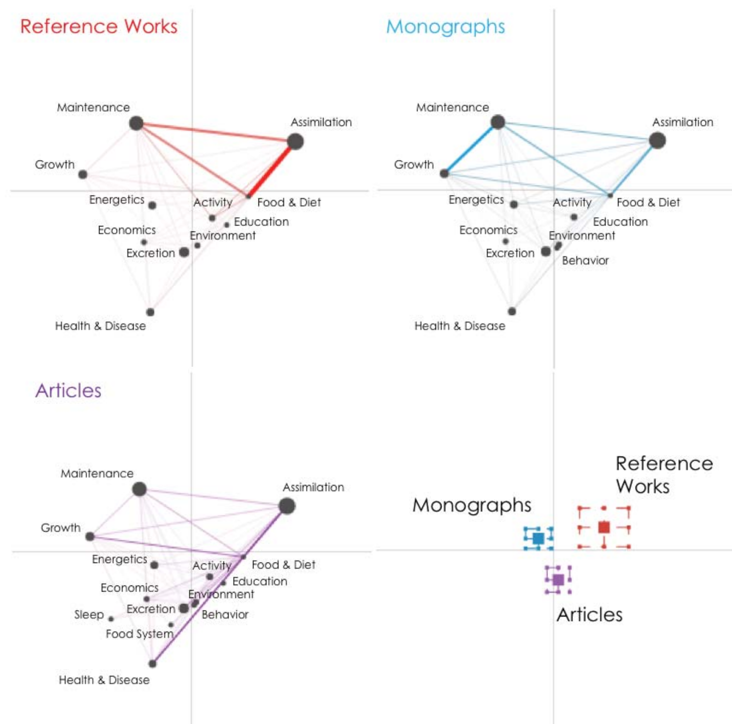

Figure 8.7: Mean ENA networks of nutrition definitions by type of source, and the mean ENA network locations with the corresponding 95% confidence intervals. All means are statistically significantly different ($p < 0.05$) with moderate-to-large effect sizes ($r > 0.40$).

In addition, the ENA model can be used to explore the impact of a particularly influential individual. In 1909, the American chemist Graham Lusk published the second edition of *The Elements of the Science of Nutrition*. In it, he defined nutrition as "the sum of the processes concerned in the growth, maintenance, and repair of the living body as a whole or of its constituent organs."[45] This was the most commonly cited definition of nutrition in the English-language literature. In the dataset analyzed here, 17 (11%) of the 155 definitions published between 1910 and 1999 referenced Graham's definition, even when proposing a broader one. Figure 8.8 shows the ENA difference graph—which is produced by subtracting one mean network from another—for sources that cited Graham and those that did not. Connections shown in blue were stronger among the sources that cited Graham, while connections shown in red were stronger among the sources that did not cite Graham. As the difference graph indicates, the connection between *growth* and *maintenance* was far more common in definitions that cited Graham's

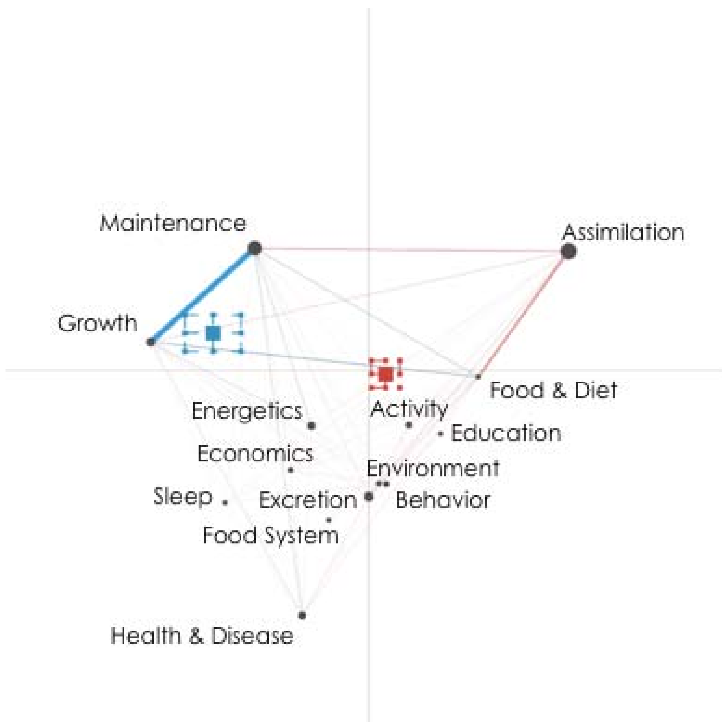

Figure 8.8: ENA difference graph showing the differences between the mean networks of nutrition definitions that cited Graham Lusk (blue) and those that did not (red). The means are statistically significantly different ($p < 0.01$) with a large effect size ($r = 0.86$).

definition, while most other connections, with the exception of the connection between *assimilation* and *food and diet*, were relatively similar in both. The difference is statistically significant on the first (x) dimension with a large effect size: Mann-Whitney's $U = 3702$, $p < 0.01$, $r = 0.86$.

Thinking about the Past as a Dataset–A Reflection on Historical Research Methods

The goal of this exploratory study is not to provide a definitive analysis of the meaning of nutrition over 200 years. Neither is it to suggest that a mixed-methods approach to historical research is necessarily better than an exclusively qualitative approach, nor even to argue that all historical research would benefit from the incorporation of modeling or quantitative methods. Rather, because a mixed-methods approach provides additional tools with which to explore historical sources, it can be a very useful way to expand what historians can do to understand the past.

In this case, the study suggests that ENA models can provide several advantages over qualitative analysis alone. As the initial results illustrate, the models can be used to provide quantitative support for a hypothesis developed qualitatively. I had always believed, based on years of studying the topic, that nutrition as a concept became more holistic and ecological over time, and that this was part of why so many nutritionists expressed varying levels of concern about the nebulous identity of the field. It also fit with the ever expanding list of professionals who considered nutrition a core area of focus; as more and more groups claimed nutrition as part of their purview, it is only natural that nutrition itself would expand to accommodate the wider range of interests. But given the timespan over which these developments took place, it was difficult to know whether these impressions resulted from my idiosyncratic engagement with the material, which was mostly through the literature on public health nutrition, and it was equally difficult to know whether this impression would actually stand up to a systematic approach to the question.

In addition to hypothesis *testing*, where ENA models can be used to confirm (or at least provide additional support for) theories generated by qualitative analysis, hypothesis *generation* is another affordance of mixed-methods approaches. Once an ENA model is created, for example, it can be used to quickly explore a range of relationships, generating new questions for further qualitative and quantitative analysis. In this case, the model can enable rapid exploration of differences in definitions across media, or examination of the effect on the community of a particularly influential member. Conducting these analyses qualitatively would be far more labor intensive. Thus, these exploratory uses of ENA (or other quantitative models) can be used to identify questions that are likely to be worth further examination. For example, the code *sleep* appears only in the network for 1930–1959. This raises an obvious question: why was sleep seen as an important component of nutrition in that period, but not in any of the others? A similar question could be asked of *education*, which appeared in definitions published only in 1960–1999.

Of course, it is important to understand not only the affordances but also the limitations of network analysis. One key limitation is that a network model cannot show you what isn't there. In the case of nutrition, for example, one code that is not part of the model is body weight. Although weight has become increasingly prominent in discussions of nutrition over the course of the twentieth century, and especially in the early twenty-first century, it appeared in only 5 of the 228 definitions analyzed. Discussion of race and gender were even more rare in nutrition definitions, but as anyone who has studied the history of nutrition can attest, both race and gender were frequently invoked concepts in nutrition discourse more broadly. The fact that these concepts do not frequently appear in *definitions* is provocative in and of itself, but further work is needed to understand how they function in nutrition discourse. Thus, while analyses such as the one presented here can provide considerable insight, they can also render invisible anything not included in the model.

That being said, models can be extremely useful for both exploring historical materials and for constructing arguments about the past. Historical research can certainly benefit from—and in a growing number of cases may even require—an approach that combines traditional analysis with computational models. ENA is, of course, only one example of an approach to modeling historical material, and there are certainly more aspects of network analysis worthy of serious discussion by historians. It is my hope that this paper, and the other papers in this volume, will stimulate further discussion about how we can incorporate new approaches and tools into our historical toolkits in order to better understand the past.

Acknowledgments

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Endnotes

1. G. Budd, “Lectures on the Disorders Resulting from Defective Nutriment,” *London Medical Gazette* (July 22, 1842): 632.

2. Henry C. Sherman, “Adequate Nutrition and Human Welfare,” in *Proceedings of the National Nutrition Conference for Defense* (Washington, D.C.: U.S. Federal Security Agency, 1942), 31.

3. George T. Palmer, “The Measurement of Nutritional Status,” *Child Health Bulletin* 6, no. 2 (1930): 47.

4. While interest in nutritional processes goes as far back as written records in most cultures, this project focuses on nutrition in the nineteenth and twentieth centuries, which marked a shift in nutrition discourse. Nutrition as a concept distinct from metabolism emerged only around the turn of the nineteenth century in Europe. Moreover, the Hippocratic-Galenic dietetic tradition and use of analogical reasoning to understand the relationship between diet and health had largely transitioned to an experimental and universalizing epistemology by the nineteenth century. See, for example, Frederic L. Holmes, “The Transformation of the Science of Nutrition,” *Journal of the History of Biology* 8, no. 1 (1975): 135–144; Steven Shapin, “‘You Are What You Eat’: Historical Changes in Ideas about Food and Identity,” *Historical Research* 87, no. 237 (2014): 377–392.

5. George Dow Scott, *Heredity, Food, and Environment in the Nutrition of Infants and Children* (Boston: Chapman and Grimes, 1942), 320.

6. Christine E. Rossington, “Environmental Aspects of Child Growth and Nutrition: A Case Study from Ibadan, Nigeria,” *GeoJournal* 5, no. 4 (1981): 347; cf. Howard A. Schneider, “Toward a Philosophy for Nutrition,” in *Human Nutrition Historic and Scientific*, ed. Iago Galdston (New York: International Universities Press, 1960), 225–232.

7. Kirsten Utheim Toverud, Genevieve Stearns, and Icie G. Macy, *Maternal Nutrition and Child Health: An Interpretative Review* (Washington, D.C.: National Research Council, 1950), 3.

8. Classic studies of definition, classification, and discourse in the history of science and medicine include Ludwik Fleck, *Entstehung und Untwicklung einer wissenschaftlichen Tatsache: Einführung in die Lehre vom Denkstil und Denkkollektiv* (Basel: Benno Schwabe and Co., 1935); Michel Foucault, *L’Archéologie du Savoir* (Paris: Gallimard, 1969); Ian Hacking, *The Taming of Chance* (Cambridge: Cambridge University Press, 1990). On discourse analysis, see Norman Fairclough, *Discourse and Social Change* (Wiley, 1993); James Paul Gee, *An Introduction to Discourse Analysis: Theory and Method*, 4th ed. (London: Routledge, 2014).

9. In this paper, I am elaborating ideas first outlined in A. R. Ruis and David Williamson Shaffer, “Annals and Analytics: The Practice of History in the Age of Big Data,” *Medical History* 61, no. 1 (2017): 336–39.

10. William J. Turkel, *Digital History Hacks (2005-08): Methodology for the Infinite Archive* (blog), http://digitalhistoryhacks.blogspot.com.

11. Shawn Graham, Ian Milligan, and Scott Weingart, *Exploring Big Historical Data: The Historian’s Macroscope* (London: Imperial College Press, 2016).

12. David Williamson Shaffer, Wesley Collier, and A. R. Ruis, "A Tutorial on Epistemic Network Analysis: Analyzing the Structure of Connections in Cognitive, Social, and Interaction Data," *Journal of Learning Analytics* 3, no. 3 (2016): 9–45; David Williamson Shaffer and A. R. Ruis, "Epistemic Network Analysis: A Worked Example of Theory-Based Learning Analytics," in *Handbook of Learning Analytics*, ed. Charles Lang et al. (Society for Learning Analytics Research, 2017), 175–87; David Williamson Shaffer, *Quantitative Ethnography* (Madison, WI: Cathcart Press, 2017).

13. On the importance and challenges associated with definitions of health and disease, see, for example, Georges Canguilhem, *Essai Sur Quelques Problèmes Concernant Le Normal et Le Pathologique* (Clermont-Ferrand, 1943); Gretchen A. Condran and Jennifer Murphy, "Defining and Managing Infant Mortality: A Case Study of Philadelphia, 1870–1920," *Social Science History* 32, no. 4 (2008): 473–513; Jenny Doust, Mary Jean Walker, and Wendy A. Rogers, "Current Dilemmas in Defining the Boundaries of Disease," *Journal of Medicine and Philosophy* 42 (2017): 350–66; Jeremy A. Greene, *Prescribing by Numbers: Drugs and the Definition of Disease* (Baltimore: Johns Hopkins University Press, 2006); Maël Lemoine, "Defining Disease beyond Conceptual Analysis: An Analysis of Conceptual Analysis in the Philosophy of Medicine," *Theoretical Medicine and Bioethics* 34, no. 4 (2013): 309–25; Wendy A. Rogers and Mary Jean Walker, "The Line-Drawing Problem in Disease Definition," *Journal of Medicine and Philosophy* 42 (2017): 405–23; A. R. Ruis, "'Children with Half-Starved Bodies' and the Assessment of Malnutrition in the United States, 1890–1950," *Bulletin of the History of Medicine* 87, no. 3 (2013): 380–408; Matthew Smith, *Another Person's Poison: A History of Food Allergy* (New York: Columbia University Press, 2015).

14. "L'impossibilité d'isoler la Nomenclature de la science et la science de la Nomenclature, tient à ce que toute science physique est nécessairement formée de trois choses: la série des faits qui constituent la science; les idées qui les rappellent; les mots qui les expriment. Le mot doit faire naître l'idée; l'idée doit peindre le fait: ce sont trois empreintes d'un même cachet." Antoine Lavoisier, *Traité Élémentaire de Chimie*, 2nd ed. (Paris, 1793), I.vi.

15. Terrence W. Deacon, *The Symbolic Species: The Co-Evolution of Language and the Brain* (W. W. Norton, 1998), 83.

16. Ludwik Fleck, *Genesis and Development of a Scientific Fact*, eds. Thaddeus J. Trenn and Robert K. Merton, trans. Fred Bradley and Thaddeus J. Trenn, (University of Chicago Press, 1979), 39. On communities of practice more generally, see Etienne Wenger, *Communities of Practice: Learning, Meaning, and Identity* (Cambridge University Press, 1998).

17. Ibid.

18. Charles E. Rosenberg, "Disease in History: Frames and Framers," *Milbank Quarterly* 67, no. S1 (1989): 1.

19. Timothy Shortell, "The Rhetoric of Black Abolitionism: An Exploratory Analysis of Antislavery Newspapers in New York State," *Social Science History* 28, no. 1 (2004): 77.

20. Jean-Baptiste Michel et al., "Quantitative Analysis of Culture Using Millions of Digitized Books," *Science* 331, no. 6014 (2011): 176–182.

21. Google Books Ngram Viewer, Retrieved from http://books.google.com/ngrams

22. Claude Bernard, *Rapport sur la Progrès et la Marche de la Physiologie Générale en France* (Paris, 1867), 93.

23. Aristotle, *On the Soul*, *Parva Naturalia*, *On Breath*, trans. W. S. Hett (Harvard University Press, 1957), 434a22 ff.

24. E. Leigh, *Respiration Subservient to Nutrition: A Thesis Presented to the Medical Faculty of Harvard University, March, 1850* (Boston: Ticknor, Reed and Fields, 1853), 1.

25. Theo. L. Hatch, "Nutrition, with a Report of Some Cases of Mal-Nutrition," *Northwestern Lancet* 9 (1889): 158.

26. A. Richerand, *The Elements of Physiology*, trans. Robert Kerrison (Philadelphia: Hopkins and Earle, 1808), 194.

27. See Ruis, "'Children with Half-Starved Bodies.'"

28. Franz Knoop, "Some Modern Problems in Nutrition," *Johns Hopkins Hospital Bulletin* 24, no. 268 (1913): 175.

29. Ira S. Wile, "What Do We Mean by Nutrition?" *Hospital Social Service Quarterly* 4, no. 3 (1921): 111.

30. L. Emmett Holt, *Food, Health and Growth: A Discussion of the Nutrition of Children* (New York: The Macmillan Co., 1922), 4.

31. Harold Himsworth, "What 'Nutrition' Really Means," *Nutrition Today* 3, no. 3 (1968): 20.

32. "Nutrition Definition," *Nutrition Today* 4, no. 1 (1969): 26.

33. On nutrition science and policy during this period, see Kenneth J. Carpenter, "A Short History of Nutritional Science: Part 1 (1785–1885)," *Journal of Nutrition* 133 (2003): 638–45; "A Short History of Nutritional Science: Part 2 (1885–1912)." *Journal of Nutrition* 133 (2003): 975–84; "A Short History of Nutritional Science: Part 3 (1912–1944)," *Journal of Nutrition* 133 (2003): 3023–32; "A Short History of Nutritional Science: Part 4 (1945–1985)," *Journal of Nutrition* 133 (2003): 3331–42; Holmes, "The Transformation of the Science of Nutrition"; Molly S. Laas, "Nutrition as a Social Question: 1835–1905" (Ph.D. Thesis, University of Wisconsin–Madison, 2017); Elizabeth Neswald, David F. Smith, and Ulrike Thoms, eds., *Setting Nutritional Standards: Theory, Policies, Practices* (University of Rochester Press, 2017); Aleck Samuel Ostry, *Nutrition Policy in Canada, 1870–1939* (Vancouver: University of British Columbia Press, 2011). The quantitative turn engendered what some scholars have termed "nutritionism" or "hegemonic nutrition," the construction of dietetic self-management as a performance of one's moral rectitude or social fitness. See, for example, Charlotte Biltekoff, *Eating Right in America: The Cultural Politics of Food and Health* (Durham: Duke University Press, 2013); Jessica J. Mudry, *Measured Meals: Nutrition in America* (Albany: State University of New York Press, 2009); Gyorgy Scrinis, *Nutritionism: The Science and Politics of Dietary Advice* (New York: Columbia University Press, 2013).

34. E. P. Cathcart, *Nutrition and Dietetics: Our Food and the Uses We Make of It* (London: Ernest Benn, Ltd., 1928), 3.

35. Laas, "Nutrition as a Social Question: 1835–1905," 3.