Lawrence Joseph Henderson: Bridging Laboratory and Social Life

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A dissertation presented

by

Mateo J. Muñoz

to

The Department of History of Science

in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy
in the subject of
History of Science

Harvard University
Cambridge, Massachusetts

May 2014

Dissertation Advisor: Professor Charles E. Rosenberg Mateo J. Muñoz

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Abstract

This study uses the professional trajectory of the Harvard-trained physical chemist and physiologist Lawrence Joseph Henderson to show how the nascent and highly mobile interconnections between biomedicine and social theory began to crystallize around the concept of the *social system* in the middle decades of the twentieth century. The social system became a powerful and persuasive way of relating vastly different concepts and their consequences, e.g., the laboratory and social life. By focusing on L.J. Henderson and the social system, this study brings the history of biomedicine into dialogue with the history of the social sciences in a new and interesting way by offering an alternative (pre-cybernetics) genealogy of systems theory. This dissertation is an examination of Henderson's cross-disciplinary application of the concept of the social system in three domains: the social sciences, medicine, and industry. Henderson is a historically interesting case because he allows us a unique point of view—the ability to see border crossings between the social sciences and the life sciences in more than one domain. I argue that the transformation of social theory in inter-war America should be understood as part of a broader set of mid-twentieth century developments in the life sciences in general, and human physiology in particular.

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LIST OF ABBREVIATIONS

APA	American Philosophical Association
APS	American Philosophical Society
CIBP	Chester I. Barnard Papers, Baker Library, Harvard Business School, Harvard University
CML	Countway Medical Library
CWI	Committee of Work in Industry
DMS	Division of Medical Sciences
HBS	Harvard Business School
HFL	Harvard Fatigue Laboratory
HMS	Harvard Medical School
HUA	Harvard University Archives
LJHP	L.J. Henderson Papers, Baker Library, Harvard Business School, Harvard University
MGH	Massachusetts General Hospital
RAC	Rockefeller Archive Center
RPP	Raymond Pearl Papers

ACKNOWLEDGEMENTS

For my parents

INTRODUCTION

Lawrence Joseph Henderson: Bridging Laboratory and Social Life tracks early- and mid-twentieth century interactions between the social sciences and the life sciences through the professional trajectory of Harvard physiologist and physical chemist Lawrence Joseph Henderson. Henderson is most clearly remembered within the history of the life sciences for conducting research and publishing papers on the regulation of acid-base equilibria in living organisms and deriving the eponymous principle of equilibrium (the Henderson-Hasselbach equation). Henderson later developed a theory of the social system, which he applied to medicine and the psycho-physiology of work. This dissertation is an examination of Henderson's cross-disciplinary application of the concept of the social system in three domains: the social sciences, medicine, and industry. Henderson is a historically interesting case because he allows us a unique point of view—the ability to see border crossings between the social sciences and the life sciences in more than one domain. Henderson's life provides a comparative frame for these three domains in a single figure. That itself is quite unusual, and is worth exploring.

Henderson's work assumes the existence of interdisciplinarity. Scholars have frequently looked at interdisciplinarity from the perspective of established disciplines that were once interdisciplinary fields struggling to establish themselves (biochemistry, physical chemistry, psychiatry, sociology), or from the perspective of such failed projects as human relations, human biology, or general physiology. In this case, the focus is less on success or failure in establishing a distinct discipline, and more on the nature of the border crossings. In this dissertation I use Henderson as a lens to examine the porousness of these boundaries, with the goal of understanding moments of interaction between the life sciences and the social sciences and the institutional conditions that enabled this type of movement of bodies and ideas.

Each chapter in this dissertation provides an analytic that allows us to learn something new about the porous boundaries between the life sciences and the social sciences in the early decades of the twentieth century. By exploring these differential border crossings between the social and the biological—within the space of industrial labor studies, within social medicine and within the social and biological sciences—we see a more robust picture of the dynamics of interdisciplinarity in the pre-war period than is generally suggested in existing histories of these fields.

My secondary goal is to show that the distance between Henderson's intellectual moment and ours is at least part of the reason why we have separated these intellectual spheres in our minds. Henderson is not an outlier, but rather an indicator to study a very different moment in time when such border crossings were actually not that difficult. Today, this kind of border crossing is considered quite difficult, largely due to existing institutional structures and disciplinary dynamics as well as professional priorities. This is made evident, for instance, in the existence of the so-called translational sciences. Translational science refers to the movement of scientific developments from bench to bedside.

This study is not the first account to consider Henderson's life and work. Other scholars have considered him and his writings, especially in the history of science. Sarah Tracy, for example, has extensively studied the Harvard Fatigue Laboratory and the work of Ancel Keys, a prominent physiologist who conducted research at the Harvard Fatigue Laboratory. Her interest in exercise physiology and the physiology of extremes has helped us better understand the motivations and values of these large-scale research projects in physiology and human biology.[1]

[1] Sarah W. Tracy, "The Physiology of the Extremes: Ancel Keys and the International High Altitude Expedition of 1935," *Bulletin of the History of Medicine* 86, no. 4 (2012): 627–660.

Joel Isaac has focused largely on the circulation of ideas in the social sciences.[2] His work has taught us much about the role institutions—especially inter-war Harvard—play in the circulation and production of social scientific knowledge and the establishment of disciplines.

This dissertation will draw heavily on these important works with the goal of understanding moments of bifurcation and crossing-over between the biological and the social sciences. As such, this dissertation moves our understanding of the development of the social and biological sciences in the twentieth century into different spaces—beyond the Harvard Fatigue Laboratory and beyond the Ivory tower—to the industrial workplace and the clinic. My interest in these border crossings is the very thing that brings focused attention to these different spaces. It is here that we can more clearly see the bifurcation of these domains—social science, medicine, and the industrial workplace—from different perspectives. I argue that bifurcation and crossing over are essential to understanding what was happening in these domains. As such, this study gives us a fresh look at the interface between social medicine and industry as well as the history of interdisciplinarity.

Henderson is not the only person who engaged in border crossing. Henderson's particular training and institutional location, however, enabled him to cross through domains ranging from physiology to sociology to social medicine to industrial research. Each of these domains gives new insight into the differential nature of disciplinary crossing at that particular moment in time.

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[2] Joel Isaac, *Working Knowledge: Making the Human Sciences from Parsons to Kuhn*, (Cambridge, MA: Harvard Universty Press, 2012).

The Social System

Early in his career, Henderson began studying logic with the famous American philosopher Josiah Royce. The two men developed an enduring intellectual friendship that in many ways transformed Henderson's approach to scientific inquiry. While attending Royce's seminar on logic, starting in 1913, Henderson was exposed to symbolic logic. This was also the first time Henderson thought seriously about the "speculative problems raised by the natural sciences."[3] Henderson emerged from the seminar interested in social theory and the philosophical implications of his scientific work. Nowhere is this more apparent than in his first two books intended for popular audiences, *The Fitness of the Environment* (1913) and *The Order of Nature* (1917).[4] In the years following the publication of *The Order*, Henderson's influence as an authority on systems thinking rose, eventually culminating in a 1927 grant from the Rockefeller Foundation to establish a laboratory to study the psycho-physiology of work in industry. The resultant structure—the Harvard Fatigue Laboratory (HFL)—would become an unusually powerful vehicle coordinating funding and researchers across a broad range of research domains. Henderson's involvement as director of the HFL marks his growing interest in the interface between systems theory, social order, and physiology.

The HFL must be understood within the context of rapid institutional growth that characterized Harvard—and the American university in general—in the early twentieth century. Under the leadership of President A. Lawrence Lowell, Harvard University more than doubled its endowment, student body, faculty, and infrastructure. L.J. Henderson's ideas about the nature

[3] W.P. Montague, "The Oxford Congress of Philosophy," *The Journal of Philosophy* 18, no. 5 (1921): 128.

[4] Lawrence Joseph Henderson, *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter*, (New York: Macmillan, 1913); Lawrence Joseph Henderson, *The Order of Nature* (Cambridge, MA: Harvard University Press, 1917).

of social interaction, human relationships, and social order flourished within this context of rapid growth and change. Henderson made little distinction between the class of subjects appropriate for social scientific inquiry and those requiring a life sciences approach—the topics differed only in that one dealt with the interactions between one or more persons and the other did not. What the social sciences lacked, he argued, was a scientific formulation, a theory or working hypothesis or even a rough conceptual scheme with which to study these interactions *between* individuals. His life work was to develop a transdisciplinary approach to studying both social and biological systems.

As his work in the Fatigue Laboratory increasingly required him to see individuals within the context of their social worlds—such as the workplace—Henderson's interests in social theory became more concrete. Henderson found Pareto's notion of the "social system" a particularly useful alternative to a "cause-and-effect" understanding of social interaction. Unlike a cause-and-effect analysis that posits a one-to-one relationship between variables, Pareto's conceptual scheme offered a way of analyzing simultaneous variations of mutually dependent variables.[5] This notion of the system, Henderson urged, was a "genuine abstraction, useful despite the fact that it was a creation of the imagination." The power of the system was not in its concreteness but in its ability to make concrete things intelligible: "Systems imposed boundaries and mapped out relationships: within them, facts made sense." It was this promise of an effective and dynamic interpretive framework with which to study social phenomena that made Henderson's articulation of the social system so compelling to his contemporaries.

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[5] On the most general level, a system consists of variables that are in a state of mutual dependence, each individual related to the other through logical necessity. In the case of social analysis, interactions between two or more persons, the 'social system' was thought to consist of heterogeneous individuals with a range of affiliations, such as church, school, family, from different social and class backgrounds. For an overview of Pareto's *Trattato di sociologia generale* see George C. Homans and C.P. Curtis, Jr., *An Introduction to Pareto, His Sociology,* (New York: A. A. Knopf, 1934).

When applied to the study of social phenomena, the concept of the *social system* gave rise to a new and powerful notion of what social life was and what social science was for. By the late 1930s a new approach to studying social life was underway, one that was, at least in its intent, more aligned with recognizable "scientific" modes of inquiry in that it stressed the importance of standardized methodologies, an ideological commitment to objectivity, and efforts to develop a *generalized* description of social phenomena. Henderson epitomized this movement, in that he saw the problem of developing a method to understand non-logical human action as logically analogous to understanding blood physiology. Henderson offered a way of extending a method that had been successfully applied to reasoning about biological systems to reasoning about human action. Just as in physiology, the implications of this emergent systems analysis of life and social life were not immediately obvious. Knowledge gained using emergent social scientific methods could be applied to a situation immediately at hand, for instance, devising interventions to create a more efficient and effective workplace. But the methods could also be used to improve the interpretative potential of the conceptual scheme itself, for instance by studying a broader range of people engaged in a broader range of activities.

The emergence of a naturalistic understanding of social life, with a concomitant confidence in the ability to render social life intelligible through scientific investigation and systematic generalization, has had profound implications for the social sciences, the sciences, and systems of governance. Henderson's writings and teachings on the social system provided researchers in the natural and social sciences a language and a logic by which to make social life intelligible. This new systems view of life can be traced back to early-twentieth-century developments in physiology in general and human physiology in particular. Henderson stood at

the center of these developments, and his life provides us with a lens through which we can make sense of the emergence of a new relationship between the life sciences and the social sciences.

Methodological/Theoretical Considerations

L. J. Henderson makes a fitting subject for a dissertation on transdisciplinary systems thinking for a number of practical, historiographical, and theoretical reasons. As a practical matter, Henderson's papers—conveniently located at Harvard, where Henderson spent most of his professional career—contain a unique and extensive record of the types of interactions between the social sciences and the life sciences that this dissertation seeks to investigate. But while this dissertation considers Henderson's work in detail, it is not conceived as a biography of Henderson's own life in a strict sense. Instead, the study unravels the various ways in which Henderson's biography interacts with the trajectories of other prominent figures—Talcott Parsons, Chester Bernard, Elton Mayo, Pitirim Sorokin, and W. B. Cannon, to name a few—and how his work relates to the development of a new framework for studying biological and social life. The dissertation will therefore move back and forth between the specifics of Henderson's intellectual and social trajectories and the points at which his biography intersects with other key elements in the development of the social and the life sciences.

The choice of Henderson is, however, more than a matter of convenience. It is a central claim of this dissertation that Henderson played an important role in reconfiguring the boundaries between the social and the life sciences in the interwar years. While Henderson is not exactly absent from the historiography, published accounts of his life and work have depicted Henderson as a brilliant but vain and domineering man whose privileged position in life rendered him oblivious to the 'real world' problems of his time. In general, little effort has been made to understand Henderson's work—both in the life sciences and the social sciences—within the

context of intellectual life at Harvard in the 1920s and 1930s.[6] When scholars have focused on the specifics of Henderson's views, they have usually focused on Henderson's theory of equilibrium and his conception of the organism as in a state of dynamic equilibrium with its environment.[7] Other scholars have attempted to make sense of how and why Henderson moved from physical chemistry, to physiology, and finally to sociology.[8] By focusing too narrowly on factors motivating Henderson's work, these approaches miss an opportunity to raise larger questions about the development of physiology, medicine, and the social sciences.

A more interesting and historically relevant question might ask how Henderson's work in physiology—especially his work on fitness and adaptability—put him in dialogue with people asking questions about the nature of social change. What, in other words, does the ready acceptance of Henderson's interpretation of the social system suggest about the state of physiological and social research in the 1930s and 1940s? Two works have examined this problem by making claims about intellectual priority. In her widely cited article on the Harvard Pareto Circle, Barbara Heyl states that one of her goals was to "determine whether Henderson was indeed the one who shaped the thinking of the other scholars reading these [Paretian]

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[6] For biographical accounts by historians and contemporaries of Henderson see David B. Dill, "L.J. Henderson, His Transition from Physical Chemist to Physiologist; His Qualities as a Man," *The Physiologist* 20 (1977):1–15; Jean Mayer, "Lawrence J. Henderson," *Journal of Nutrition* 94 (1968): 1–5; W.B. Cannon, "Biographical Memoir of Lawrence Joseph Henderson 1878–1942," *National Academy of Sciences of the Unite d States* 23, (1943): 31–58; Dickinson W. Richards, "Lawrence Joseph Henderson," *Physiologist* 1, no. 3 (1958):32–37; John H. Talbott, "Lawrence Joseph Henderson (1878–1942), Natural Philosopher," *Journal of the American Medical Association* 198 (1966): 1304–1306; Crane Brinton, "Lawrence Joseph Henderson, 1878–1942," in *The Saturday Club: A Century Completed, 1920–1956*, eds. E.W. Forbes and J.H. Finlay, (Boston: Houghton Mifflin, 1958), 207–214.

[7] Cynthia Eagle Russett, *The Concept of Equilibrium in American Social Thought*, (New Haven, CT: Yale University Press, 1966).

[8] For Everett Mendelsohn's account, see Mendelsohn, "Locating 'Fitness' and L.J. Henderson," in *Fitness of the Cosmos for Life: Biochemistry and Fine-Tuning*, eds. John D. Darrow, Conway Morris, Stephen J. Freeland, Charles L. Harper, Jr., (Cambridge: Cambridge University Press, 2008), 3–19.

concepts."[9] Similarly, Bernard Barber's introduction to *On the Social System*—an edited volume of Henderson's lecture notes and selected published works—opens by asking, "Was Henderson a Sociologist?"[10] Both authors seek to delineate the exact impact Henderson had on the development of sociology as an academic discipline. Each comes to a similar conclusion: Henderson had an influence on individual sociologists within a very specific historical moment, but no direct influence on the field in general.

There is also a literature that places L.J. Henderson's work within the history of biology. There has not been much work in this area, and the work that has been published is now over forty years old. The most extensive scholarly work on this topics has been written by two historians of biology—John Parascandola and Iris Fry.[11] This dissertation will draw on their discussions of the intellectual history of Henderson's biological studies but clearly moves the analysis in a different direction. Historian Thomas Hankins has also published an article on the

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[9] B. S. Heyl, "The Harvard 'Pareto Circle,'" *Journal of the History of the Behavioral Sciences* 4, no. 4 (1968): 316–334.

[10] Bernard Barber, "Introduction," in Lawrence J. Henderson, *On the Social System: Selected Writings*, ed. Bernard Barber, (Chicago: University of Chicago Press, 1970), 1–20.

[11] John Parascandola, "Lawrence J. Henderson and the Concept of Organized Systems" (PhD diss., University of Wisconsin, 1968). A modified version of his dissertation appears in Parascandola, "Organismic and Holistic Concepts in the Thought of L.J. Henderson" *Journal of the History of Biology* 4, no.1 (1971): 63–113; Iris Fry, "On the Biological Significance of the Properties of Matter: L.J. Henderson's Theory of the Fitness of the Environment" *Journal of the History of Biology* 29, no.2 (1996): 155–196; Iris Fry, *The Emergence of Life on Earth: A Historical and Scientific Overview* (New Brunswick, NJ: Rutgers University Press, 2000). This section will only discuss works that have not been mentioned in prior sections. Jerome Lowenstein has also written a biographical novel featuring Henderson which draws on Henderson's unpublished semi-autobiography and personal papers found in the Harvard Archives. See Jerome Lowenstein, *Henderson's Equation: A Novel*. (Great Barrington, MA: Gadd & Co., 2008).

development of nomographic techniques in general, and Henderson's use of nomographic techniques to study blood physiology.[12]

A simpler version of this dissertation might attempt to trace the most important ideas in twentieth-century American social thought back to Henderson and the Pareto Circle, focusing on rectifying factual and methodological flaws in these existing studies. As is, battles over priority have made it difficult to raise new questions about the intellectual exchange between researchers in the social sciences and the life sciences and the factors that made certain kinds of interactions not only possible but necessary. What these impassioned claims to priority nevertheless reveal is that a powerful notion of what social life was had greatly influenced the way sociological research was conducted and the types of research questions raised in the mid-twentieth century.

The goal of this dissertation is instead to both complicate the received narrative and to offer a new way of thinking about the history of the relationship between the life sciences and the social sciences. In addition, this dissertation demonstrates that this new understanding of social life must be understood against the backdrop of important developments within the life sciences. Reconstructing what this notion of social life was, how it was studied, its relationship to developments in the life sciences, and the problematic from which it emerged is a central goal of this dissertation.[13]

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[12]Thomas L. Hankins, "Blood, Dirt, and Nomograms: A Particular History of Graphs," *Isis* 90, no.1 (1999): 50–80.

[13]My initial curiosity about what "social life" as a concept and object of study in the 1930s was inspired by Steven Shapin's thoughtful discussion of Merton's early work in Shapin, "Understanding the Merton Thesis," *Isis* 79, no. 4 (1988): 594–605. In this article Shapin notes that there is something about the general orientation of Merton's thesis that we should not allow to disappear from our view (605). He points out that "The problematic from which Merton's work emerged in the 1930s was one that accepted the interest, importance, and legitimacy of macrosociological theorizing about the historical development and social setting of culture (605)." I would argue that this general orientation in Merton's work was akin to Henderson's systems worldview of life and social life. Both Merton and Henderson's work is characterized by a drive toward generalized abstraction and an effort to draw connections among disparate parts at the highest level of abstraction.

In tracking the interactions between scholars in the social sciences and scholars in the life sciences, this dissertation also draws on the work of historians who have written on other members of the Harvard Pareto circle, including Talcott Parsons,[14] Elton Mayo,[15] Chester I. Barnard,[16] A. Lawrence Lowell,[17] and George C. Homans.[18] My account additionally draws on

[14] Talcott Parsons has been the subject of a number of studies written by historians as well as sociologists. The bulk of the scholarship written by sociologists is in the form of interpretive essays and anthologies elaborating Parsons' contributions to sociology. Historical scholarship on Parsons tends to focus on the postwar period. The first published biography of Parsons was written by his former student Uta Gerhardt. Gerhardt, *Talcott Parsons: An Intellectual Biography*, (Cambridge: Cambridge University Press, 2002). In addition to Gerhardt's intellectual biography, Tuk-Sang Pyun produced an unpublished biographically oriented dissertation on Talcott Parsons in 2002. Pyun, "Science, Social Science, and Society: Natural Images in Talcott Parsons' Social Theory," (PhD diss., Harvard University, 2002). See also Howard Brick, "Talcott Parsons' 'Shift Away from Economics,' 1937–1946," *The Journal of American History* 87, no.2 (2000): 490–514; Howard Brick, *Transcending Capitalism: Visions of a New Society in Modern American Thought*, (Ithaca, NY: Cornell University Press, 2006); Charles Comic, "The Making of a Method: A Historical Reinterpretation of the Early Parsons," *American Sociological Review* 52, no.4 (1987): 421–439; Joel Isaac, "Theorist at Work: Talcott Parsons and the Carnegie Project on Theory, 1949–1951," *Journal of the History of Ideas* 71, no.2 (2010): 287–311; Robert B. Owens, "Producing Parsons' Reputation: Early Critiques of Talcott Parsons' Social Theory and the Making of a Caricature," *Journal of the History of Behavioral Sciences* 46, no.2 (2010): 165–188.

[15] Mayo is often discussed in the context of the history of industrial sociology, anthropology, organizational theory, industrial relations, and the history of management. See Andrea Gabor, *The Capitalist Philosophers: The Geniuses of Modern Business, Their Lives, Times and Ideas*, (New York: Times Business, 2000); R. C. S. Trahair, *The Humanist Temper: The Life and Work of Elton Mayo* (New Brunswick, NJ: Rutgers University Press, 1984). For a historical account of Mayo's role in the Hawthorne studies see Richard Gillespie's excellent book, Gillespie, *Manufacturing Knowledge: A History of the Hawthorne Experiments* (Cambridge: Cambridge University Press, 1991). Gillespie's study also contains a helpful overview of the enormous literature that has developed in response to the Hawthorne studies.

[16] Chester Barnard, a prominent business executive and close friend of Lawrence J. Henderson, has received considerably less scholarly attention outside of the field of management and organizational behavior. The following secondary sources help illuminate biographical details about Barnard and his work on organizations: William G. Scott, *Chester I. Barnard and the Guardians of the Managerial State*, (Lawrence, KA: University Press of Kansas , 1992); William B. Wolf, *The Basic Barnard: An Introduction to Chester I. Barnard and His Theories of Organization and Management* (Ithaca, NY: Industrial Labor Relations, 1974).

[17] For biographical and autobiographical information about Lawrence A. Lowell see, Lowell, *What a University President Has Learned*, (New York: Macmillan, 1938); Henry Aaron Yeomans, *Abbott Lawrence Lowell, 1856–1943* (Cambridge, MA: Harvard University Press, 1977).

[18] An account of the Society of Fellows is provided in George Homans and O.T. Bailey, "The Society of Fellows, Harvard University, 1933–1947" In *The Society of Fellows*, edited by Crane Brinton, 2-7

historical surveys featuring such relevant institutions as the Harvard Fatigue Lab and the Harvard Business School.[19] Most of these studies raise questions about the development of a single discipline, the development of particular theory or concept, or the development of a single institution. This study brings together select aspects of these different accounts to show how these seemingly disparate developments at times reinforced and at other times transformed notions about the social and the natural world.

A key methodological challenge for this dissertation is differentiating between the social sciences and the life sciences during a period when the very boundaries between the two were being transformed. I approach this problem through the use of the actors' own analytic categories. A benefit of using actors' categories is that they allow us to gain an understanding of how these categories and boundaries functioned within their own historical and intellectual moment. A drawback of this approach is that sticking too close to these categories could lead to errors of analysis, similar to the ones made by the actors themselves. Henderson distinguished between the "life sciences" and the "social sciences" solely for the purpose of analysis: for him, the categories did not correspond to a deeper ontological distinction. The two categories will be treated as analytic distinctions that serve varying functions in the period under investigation.

(Cambridge, MA: Society of Fellows, 1948). George Homan's autobiographical account of his career is a useful source of information regarding the state of social scientific research at Harvard in the late 1930s and 1940s. See, Homans, *Coming to My Senses: The Autobiography of a Sociologist* (New Brunswick, NJ: Rutgers University Press, 1984).

[19] Steven M. Horvath, *The Harvard Fatigue Laboratory: Its History and Contributions* (Englewood Cliffs, NJ: Prentiss Hall, 1973); Gillespie, *Manufacturing Knowledge;* Sarah Tracy, "The Physiology of Extremes: Ancel Keys and the International High Altitude Expedition of 1935" *Bulletin in the History of Medicine* 86, no. 4 (2012): 627–660. Another article looks at the role of the HFL in advancing the science of work and its relationship to progressive politics of reform in the early twentieth century, Robin Scheffler, "The Fate of a Progressive Science: The Harvard Fatigue Laboratory, Athletes, the Science of Work and the Politics of Reform" *Endeavour* 35, no. 2–3 (2011): 48–54. See also Jeffrey L Cruikshank, *A Delicate Experiment: The Harvard Business School, 1908–1945* (Boston: Harvard Business School Press, 1987); Bard Cosman, *The Human Factor: The Harvard Fatigue Laboratory and the Transformation of Taylorism,* (undergraduate thesis, Harvard University,1983).

Historiographic Context

This work engages three interrelated questions: 1) How have the development of ideas in the natural sciences interacted with the development of ideas in the social sciences?; 2) How have the development of ideas in the social sciences interacted with the development of ideas in the natural sciences?; and 3) How are we to understand the dynamics of disciplinarity and interdisciplinarity in the academy during a moment of exuberant expansion of the social sciences in public life? These questions relate to multiple literatures, including the history of the social sciences, American cultural and intellectual history, and the history of medicine and physiology. In recasting the relationship between the social sciences and the life sciences as one of mutual engagement, this dissertation brings these literatures together.

Studies that have looked at the impact of the natural sciences on the social sciences cluster around two main themes: the professionalization of the social sciences and the quest for objectivity. Too frequently, studies of professionalization rely heavily on general themes such as the centralization of government, industrialization, and urbanization as a means of explaining how and why professionalization took place between 1880–1920. [20] In these accounts, professionalization is treated as a rational and self-conscious response to social change on the part of an individual or group of social scientists. One of the limitations of this approach is that it still leaves one wondering just how these subjects were able to grasp the changes that were

[20] For early writings on the "organizational synthesis" see, Louis Galambos, "The Emerging Organizational Synthesis in Modern American History," *The Business History Review* 44, no.3 (1970): 279–290; Robert H. Wiebe, *The Search for Order, 1877–1920* (New York: Hill and Wang, 1967).

taking place before they developed a new theory to understand the nature of that change.[21] Several of these studies share an assumption about the dynamic between technological change and social lag. This is perhaps best understood as a variant of the familiar "cultural lag" argument first proposed by sociologist William Ogburn in 1922.[22] For example, scholars often write about the various ways social forms and individuals struggle to keep up with the large-scale changes brought on by industrialization and urbanization. Changes brought about by scientific and technological developments overwhelm established social structures making it difficult to keep up with the changes. Social scientific theories and structures are always a step behind.

The natural sciences have tended to serve as a model for the professionalization of disciplines. The paradigmatic example of professionalization is medicine. Historians of medicine have complicated the notion that scientific practices were immediately and universally integrated into medicine. They have shown, for instance, how laboratory science became slowly integrated into medical practice through a series of reforms in medical education. Other historians of medicine, including Christopher Crenner, for example, have offered more sophisticated explanations of how scientific authority translated into professionalization. Crenner has argued that it was not science *per se* that gave medicine its newfound authority; rather, it was how

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[21] Thomas L. Haskell, *The Emergence of Professional Social Science: The American Social Science Association and the Nineteenth-Century Crisis of Authority*, (Urbana: University of Illinois Press, 1977; For a later study that picks up similar themes see, Thomas L. Haskell, *The Authority of Experts: Studies in History and Theory* (Bloomington: Indiana University Press, 1984). Mary Furner also looks at the relationship between social organization and social theorizing in Furner, *Advocacy & Objectivity: A Crisis in the Professionalization of American Social Science, 1865–1905*, (Lexington: University of Kentucky Press, 1975). See also Andrew Abbott, *The Systems of Professions: An Essay on the Division of Expert Labor*, (Chicago: University of Chicago Press, 1988).

[22] William F. Ogburn, *Social Change with Respect to Culture and Original Nature*, (Oxford: Oxford University Press, 1966); This text was originally published in 1922; William F. Ogburn, "Cultural Lag as Theory," *Sociology & Social Research* 41, no. 3 (1957): 167–174.

science was subsequently used and how it functioned within medicine.[23] Framing these questions of professionalization and authority in more dynamic terms allows us to raise new questions about the ways in which changes in medical education—such as the emergence of a pre-medical undergraduate curriculum, a standardized medical school curriculum, and changes in admissions standards—shaped the professionalization of the life sciences as well.[24]

One area in which scholars have considered questions of professionalization, disciplinary formation, and the hybridity of fields is in the literature on biomedicine. Scholars have examined the development of the concept of biomedicine within the context of early-twentieth-century developments in medicine and the life sciences. As scholars have noted, the term biomedicine was coined in the inter-war period. It has been conceptualized by historians of medicine and biology as a "hybrid domain, intersecting with many other scholarly disciplines."[25] Historians have characterized the development of biomedicine as a process of "molecularization" and homogenization of the methodologies used to study the phenomena of life. This dissertation examines Henderson's scientific contributions within this context and aims to show how this undeniable trend toward "molecularization" was also coupled with a growing interest in the context—the physical and social systems—in which the phenomena of life occur. This approach became increasingly out-of-step with mainstream scientific research in the years after the World War Two. While scholars have argued that biomedicine emerged out of the introduction of new

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[23] See Crenner, *Private Practice*.

[24]In his study on the development of biochemistry in the United States, Robert Kohler argues that the emergence of biochemistry as a discipline must be understood in relationship to changes in medical education. Kohler shows how this relationship was mutually beneficial. Kohler, *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline,* (Cambridge, MA: Harvard University Press, 1982).

[25] Ilana Löwy, "Historiography of Biomedicine: 'Bio,' 'Medicine,' and In Between," *Isis* 102, no. 1 (2011): 116–122.

technologies and therapies to medical practice, an underlying argument of this dissertation is that biomedicine should be understood not only as a new relationship between medicine and technology, but a new relationship between medicine and the social sciences. Biomedicine emerged out of a particular relationship between medicine and social science that has not yet been fully understood or explored by historians in general and historians of medicine in particular. A thorough examination of Henderson's work and his intellectual context provides us with a new window through which to examine the relationship between medicine and social science, a relationship that has informed how we think about and use biomedicine.

Some research on the influence of the natural sciences on the social sciences has also focused on the notion of objectivity. Historians have shown that historical actors have often seen objectivity as closely intertwined with science. Therefore, in studying how the natural sciences have influenced the development of the social sciences, scholars have focused on the tensions in research and reform created by the quest for objectivity. These studies have yielded interesting insights into the internal dynamics of the sciences during periods of professional change. However, their focus on particular scientific disciplines makes it difficult to compare and contrast trends across disciplines. This literature places the emphasis almost exclusively on the tension between fields—how it emerged, how people responded, and what the consequences were—as opposed to showing how the embrace of objectivity lead to the establishment of a discipline.[26] Historians of science, meanwhile, have greatly enhanced our understanding of

[26]Other studies taking up related themes include Robert C. Bannister, *Sociology and Scientism: The American Quest for Objectivity, 1880–1940,* (Chapel Hill: University of North Carolina Press, 1987); George Steinmetz, ed., *The Politics of Method in the Human Sciences: Positivism and Its Epistemological Others,* (Durham, NC: Duke University Press, 2005). Mark Smith looks at debates among social scientists regarding scientific methods and normative goals. He does an excellent job of showing how the embrace of objectivity was far from universal. Still in other ways he falls back on familiar assumptions—that objectivity is always linked with conservatism, and that conservatism is often linked to the culture of

objectivity by demonstrating how trust and objectivity are socially constituted through institutions, techniques, and technologies.[27]

Studies that have examined how developments in the social sciences have influenced developments in the natural sciences have not been as fruitful. [28] One approach has been to track the movement of a concept or theory from the social sciences to the life sciences. For instance, Lily Kay's work on cybernetics and the genetic code tracks how developments in information theory and the communication technosciences overlap with the elucidation of the genetic code.[29]

A different way to conceptualize the influence of the social sciences on the natural sciences is through an expansion of the concept of the "social." Sarah Igo's recent work on the popularization of social scientific ways of knowing explores how the social survey transformed

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scientific patronage. Smith, *Social Science in the Crucible: The American Debate Over Objectivity and Purpose, 1918–1941,* (Durham, NC: Duke University Press, 1994).

[27] Theodore M. Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton, NJ: Princeton University Press, 1995); and Steven Shapin, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life,* (Princeton, NJ: Princeton University Press, 1989). For a compelling set of essays on the objectivity question across different domains see, Lorraine Daston and Peter Galison, *Objectivity,* (New York: Zone Books, 2007).

[28] In studying how the content of scientific theories has impacted the social sciences a common approach has been to evaluate the correctness of the application of the scientific theories. When scholars attempt to track concepts in the other direction they tend to interpret the development of certain concepts as an expression of deeply held political ideologies. These approaches are certainly legitimate and if done carefully they can yield important and interesting insights. Some of these studies take an approach very similar to what was described earlier on the use of metaphor in the experimental life sciences. In this case social concepts and social theories about behavior are used to describe scientific objects. See for example, I. Bernard Cohen, *Interactions: Some Contacts Between the Natural Sciences and the Social Sciences* (Cambridge, MA: Harvard University Press, 1994); Russett, *The Concept of Equilibrium*; John M. Jordan, *Machine-Age Ideology: Social Engineering and American Liberalism, 1911–1939* (Chapel Hill: University of North Carolina Press, 1994); Andrew Reynolds, "The Theory of the Cell State and the Question of Cell Autonomy in Nineteenth and Early Twentieth-Century Biology," *Science in Context* 20, no.1 (2007): 71–95.; Jan Sapp, *Genesis: The Evolution of Biology* (Oxford: Oxford University Press, 2003), 75–94; Steve Sturdy, "Biology as Social Theory: John Scott Haldane and Physiological Regulation," *The British Journal for the History of Science* 21, no. 3 (1988): 315–340.

[29] Lily E. Kay, *Who Wrote the Book of Life?: A History of the Genetic Code,* (Palo Alto, CA: Stanford University Press, 2000).

Americans' understanding of themselves and society. Igo's study is also helpful in tracking the emergence of the concept of the *averaged* American and the emphasis placed on the ordinary.[30]

Implicit in this discussion is the assumption that the life sciences and the natural sciences are different disciplines, with different topics of analysis and discussion. Disciplinary histories, particularly from the history of biology and medicine, offer useful insights for understanding how researchers and institutions come to understand certain fields within their purview. As Robert Kohler's study of medicine and biochemistry demonstrates, disciplinary development is more fruitfully explored within a broader social context. Disciplinary developments should be thought of within the context of mutual dependence—the authority granted to one profession or discipline has implications for other disciplines and professions.[31]

The case of medicine is also instructive in that medicine has historically been seen as a socially relevant field. It is telling that in the 1930s social scientists started to become increasingly interested in the practice of medicine as a case study for examining inter-personal and institutional dynamics (the relationship between academic discipline and a profession).[32] The

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[30] Sarah Elizabeth Igo, *The Averaged American: Surveys, Citizens, and the Making of a Mass Public*, (Cambridge, MA: Harvard University Press, 2007).

[31] Kohler, *From Medical Chemistry*. The virtues of this approach are most clearly articulated by Charles Rosenberg in *No Other Gods: On Science and American Social Thought* (Baltimore: Johns Hopkins University Press, 1997): 225–239. Gerald Geison describes the nature of this mutual dependence between physiology and medicine as one of convenience. Medicine, having been able to gain authority through physiology and physiology, on the other hand, has maintained a comfortable position in the university as a pre-clinical science. See, Gerald Geison, "'Divided We Stand': Physiologists and Clinicians in the American Context," in *The Therapeutic Revolution: Essays in the Social History of American Medicine*, eds. Morris J. Vogel and Charles E. Rosenberg (Philadelphia: University of Pennsylvania Press, 1979), 67–90; Gerald Geison, *Physiology in the American Context: 1850-1940* (Baltimore: Williams & Wilkins, 1987). Abbott, *The Systems.*

[32]Samuel Bloom gives an account of the history of medical sociology in which he charts many of the same themes discussed above. He also points out that at Yale, the University of Chicago, University of Wisconsin, Harvard, Columbia, and Johns Hopkins, medical sociology emerged alongside sociology proper. This is an interesting fact given that the majority of these schools also had leading medical

clinical aspects of medicine made it a useful case for applying theories of social interaction. The interactions between social science and medicine are particularly useful in understanding how disciplinary developments, patronage, and social context must all be taken into consideration in developing an understanding of modern medicine.

The human, conceived as both a social and biological entity, became a particularly profitable and productive object of study for the life sciences and the social sciences in the interwar period.[33] By the 1960s, diverse scientific disciplines become oriented around understanding human life as a social and biological entity. An interesting byproduct of this shift is the way the life sciences begin to draw upon social scientific knowledge in developing research questions and programs. This can be seen quite vividly, for example, in the context of personalized medicine and epigenetic research. Mid-century life scientists came to understand the social as a generative and productive means of extracting potentially biologically relevant information about the causes and prevention of disease. As the kinds of objects that were open to social scientific study grew, so did the application of social scientific knowledge.

Chapter Overview

The remaining four chapters of this dissertation examine the development of Henderson's concept of system and the transfer of systems theory into the clinic and the industrial workplace. Each chapter aims to show how Henderson's systems theory was part of a broader effort to establish a transdisciplinary basis upon which to study organisms as biological and social beings.

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schools and substantial Rockefeller funding during the 1930s and 40s. See Bloom, *The Word As Scalpel: A History of Medical Sociology* (New York, 2002).

[33]Jack D. Pressman, "Human Understanding: Psychosomatic Medicine and the Mission of the Rockefeller Foundation," in Christopher Lawrence and George Weisz, eds. *Greater Than the Parts: Holism in Biomedicine, 1920–1950,* (Oxford: Oxford University Press, 1998): 189.

Chapter One gives an overview of who Henderson is, the factors that shaped his views, and the context of his intellectual and professional development. This chapter highlights critical turning points in Henderson's career that help to illuminate his professional contributions as well as the elaboration of systems theory through his scientific and social scientific works. This chapter additionally argues that Henderson's training and institutional location at Harvard University allowed him to move seamlessly in and out of different domains of knowledge production.

Chapter Two examines what Henderson and his contemporaries understood by "systems," in a physico-chemical sense. I provide a framework for understanding Henderson's conception of systems and contextualize the significance of Henderson's *Fitness of the Environment* (1913) and *The Order of Nature* (1917) by analyzing the reception of these two books by Henderson's contemporaries. In this chapter I outline the basic logic of systems that Henderson used to study fitness and the relationship between environment and organisms. The primacy of systems was already apparent in these two early works; Henderson used an analysis of fitness to articulate the logic of systems more generally. Henderson later transferred this same logic to his study of social interactions, a switch that will be explored in greater depth in Chapters Three and Four.

The last two chapters are dedicated to tracing Henderson's application of the concept of system to the clinical encounter and the factory floor. Chapter Three examines Henderson's conception of a social system through the case of medicine and the doctor-patient relationship—a paradigmatic example of a social system. I argue that Henderson's construction of the doctor-patient relationship as a social system is an important conceptual bridge between the laboratory and social life. Henderson's work on the doctor-patient relationship was both an application of the social system and part of a broader discussion about the need to integrate the social sciences

and the medical sciences. Henderson is not a unique figure but someone who is exemplary of this specific moment in time. The role of the social sciences has always, and perhaps shall always have, a tense relationship to medicine. In this case, Henderson attempted to bring the methods and values of physiology and biochemistry to create a disciplined (more than Hippocratic) way of studying and improving the mini-social system that constituted the doctor-patient relationship. It is this contribution and way of approaching the issue of social medicine that makes Henderson's view peculiar and allows us to look more closely at the porousness of the boundaries between the social and the biological.

Chapter Four follows the application of Henderson's concept of the social system into the industrial workplace. In this chapter I look at how the study of man—as a biological organism and social being—brought together "communities of practice" that had little pervious contact—physiologists, sociologists, psychologists, and anthropologists.[34] People such as Wallace Donham (Dean of HBS), Chester Barnard (business executive), and Elton Mayo were convinced that a deeper understanding of the underlying physiological, psychological, and social changes that mark an individual's everyday life would yield answers to the day's most vexing industrial and managerial problems. I look specifically at the making of the factory floor as a social environment through an interview program that is known as the Hawthorne Studies. The Hawthorne Studies will serve as an example of how Henderson's concept of the social system was applied to the study of the workplace. The second example consists of a series of HFL-sponsored studies on work in hot climates. The hot climate studies illustrate how physiological field research and social theory were used as an attempt to minimize the risk of worker unrest.

[34] A community of practice is a collective of people who come together on a regular basis for a common purpose. These collectives form along the lines of a commonly held interest or social role. The concept was first developed by Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation*, (Cambridge: Cambridge University Press, 1991).

Whereas the previous chapter gave an example of a conceptual bridge between the laboratory and the clinic, the HFL serves as an example of an institutional bridge between the laboratory and the factory floor.

Conclusion

This dissertation charts the continuous moments of connection between the social and biological sciences that, on reflection, can be traced back over the course of the twentieth century. What is surprising is that, when we look for them, these kinds of connections no longer seem strange; they seem natural and commonplace. Henderson's work shows us that when you look at medicine and the so-called labor sciences, it is very clear that these two fields are necessarily in conversation. Although an opposition between the biological and the social sciences may seem natural or instinctual, the idea only developed subsequent to Henderson. This dissertation shows how Henderson moved in and out of these domains of knowledge production at a time when the distinction between social science, medicine, and industry were not as rigidly determined as they are today. In so doing, this dissertation offers a new understanding of the relationship between the social sciences and the life sciences in the first half of the twentieth century.

CHAPTER ONE

The Great Nomographer

Affectionately referred to as The Great Nomographer by his close friend and colleague Raymond Pearl, Lawrence Joseph Henderson was the first to demonstrate the quantitative relationship among eight key variables in blood. By making ingenious use of d'Ocagne's technique of geometric computation known as nomography, Henderson was able to graphically represent blood as a generalized physico-chemical system. Unlike a table or chart used to summarize findings, a nomogram is used to represent multiple variables on a two-dimensional plane and yields solutions of a *general class* of similar problems rather than a solution of a single problem.[35] The rise of nomography in mid- to late-nineteenth century France corresponds with railway development in that country. The technique had previously been used primarily by military engineers to calculate the strength of railway bridges, survey land areas, and calculate the trajectory of ballistics and artillery; Henderson was the first to apply this methodology to physiology.

In a series of articles published between 1908 and 1927 Henderson advanced not only the nascent field of general physiology, but also a *systems* approach to the study of life. Life in this context refers to a technoscientific object of knowledge that can be systematically managed and studied; the instrumentalization of nature.[36] A synthetic account of these articles and lectures was later presented as part of the Silliman Memorial Lecture series at Yale University, and published

[35] H.A. Evesham, *The History and Development of Nomography* (Boston: Docent, 1982).

[36] For more on the concept of life and "life itself" see, Michel Foucault, *The History of Sexuality Vol. 1: An Introduction* (New York: Vintage, 1978); Donna J. Haraway, *Modest_Witness@Second_Millennium. FemaleMan©_Meets_OncoMouse™* (New York: Routledge, 1997).

in 1928 as a single volume titled *Blood: A Study in General Physiology*. *Blood* represents the culmination of over two decades' worth of intricate experimentation and analysis.[37] The publication of *Blood* brought Henderson the recognition he longed for from the scientific community. More so than any of his previous publications, *Blood* was well received and celebrated by the majority of L.J. Henderson's contemporaries.[38] Following the publication of *Blood*, however, L.J. Henderson began to turn most of his attention to the study of social phenomena—interactions between two or more persons—an area that he believed to be in desperate need of more rigorous, scientific formulation.[39]

Henderson came of age during a time of rapid transformation and excitement in the life sciences and the social sciences in the United States. It was a time when the U.S. emerged as the leading site for scientific medicine and research. At the turn of the twentieth century, Henderson and his contemporaries were on the verge of making major discoveries on the border of the physical and the life sciences. His work on blood physiology, in particular, illustrated not only the physiological function of blood, but also its interrelation with other parts of the body. As

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[37] The Silliman Memorial Lecture series began at Yale University in 1901. The lectures were "designed to illustrate the presence and providence, the wisdom and goodness of God, as manifested in the natural and moral world." Delivering the Silliman Lectures was considered one of America's highest honors in academic science.

[38] Lawrence J. Henderson, "Blood, A Study in General Physiology," *Science* (1929); Joseph Berkson, "The Mechanics of Teleology," *The Quarterly Review of Biology* 4, no. 3 (1929): 415–419; Lawrence J. Henderson, "Blood, A Study in General Physiology," *New England Journal of Medicine* 199, no. 22 (1928): 1126; A. W. Downs, "Blood, A Study in General Physiology," *The Canadian Medical Association Journal* (1928): 755–756; Raymond Pearl, "Metaphysics and Blood," *Science* 69, no. 1780 (1929): 161–163.

[39] Early evidence of his interest in the work of Vilfredo Pareto and other economists, can be seen in the footnotes of the first Chapter of *Blood*. Henderson notes that mathematical economists—such as Leon Walras, I. Fisher, and Pareto—have shown that mathematics is indispensible for the treatment of quantitative relations between a large number of variables. This suggests that by the spring of 1928, Henderson was thoroughly engaging the work of economists. Henderson, *Blood*, 12, footnotes 12a, 12b, and 13.

such, his study on blood physiology served as an important illustration of organic integration and adaptation. More importantly, his work gave rise to the first study that analyzed a physiological function as a set of mutually dependent variables. Prior to his blood study, physiologists had primarily looked at individual variables, for example, the concentration of lactic acid or oxygen in blood. While many researchers had speculated on the relationship between these multiple variables, they had made little progress toward an understanding of this mutual dependence. This was largely due to the relatively poor training of biologists and physiologists in mathematics and statistics. Henderson and his contemporaries, including Walter B. Cannon and C.S. Sherrington, sought to develop a more integrated vision of physiological function.

It was this demonstration of the interrelation of several discrete components of blood that moved the concept of system into physiology. The concept of the system was Henderson's heuristic of choice, and, from this concept, he was able to convey a new understanding of the elementary conditions of the phenomena of life and social life. That understanding was one that maintained that a defining characteristic of living beings was that they are "always harmoniously organized and integrated." The system then became the organizational concept that motivated much subsequent research in the realm of human physiology.

Henderson's work on the physiology of blood stands out as an early-twentieth-century breakthrough in field of general physiology in that he was able to provide scientists with a fully integrated picture of automatic acid-base regulation in the organism. His work provides an interesting contrast to studies conducted by his contemporary Jacques Loeb. As historian Philip Pauly shows, Loeb sought to define biology around the control of organisms. He considered the

exclusive aim of biology to be the control and manipulation of life-phenomena.[40] Loeb's "engineering standpoint" was one that was consistent with widespread rational reform and social engineering efforts in early-twentieth-century United States.[41] Henderson, in contrast, envisaged himself as following in the footsteps of the great French physiologist Claude Bernard. Bernard saw the main problem of biology as identifying the elementary conditions for the phenomena of life. What, in other words, is *life*, and what differentiates it from the non-living? Bernard held that the task of general physiology was to study the phenomena of life common to all animals and plants. Bernard sought to establish a *general physiology*. Henderson, like Bernard, sought to understand the elementary conditions of the phenomena of life rather than identify means for its manipulation. More importantly, he was after a clear formulation of those elementary conditions, one founded on cutting-edge developments in the physical sciences, especially the work of Willard Gibbs. Henderson considered Bernard's theory of *milieu intérieur*—the internal environment and its role in ensuring internal stability in the human organism—as encapsulating the spirit of this integrated vision of life as a physico-chemical phenomena. It was this approach that Henderson applied to the study of blood. In the second half of his career, Henderson would go on to apply this same approach to the study of social life.

In retrospect Henderson's engagement with physical chemistry, physiology, and the social sciences may appear idiosyncratic, but, in his day, Henderson was engaging in a familiar form of border crossing. What makes him unique is the fact that he was positioned in such a way that he was able to do this within a much broader set of domains. His disciplinary training in

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[40] Philip Pauly, *Controlling Life: Jacques Loeb and the Engineering Ideal in Biology*, (Oxford: Oxford University Press, 1987).

[41] John Jordan, *Machine-Age Ideology and American Liberalism, 1911–1939*, (Chapel Hill: University of North Carolina Press, 1994).

physical chemistry, medicine, and physiology allowed him to bring a quantitative tool kit to the study of biology, one that was quite rare in his day. Even his more prominent contemporaries, such as Walter B. Cannon, lacked the depth of training in mathematics to do the kind of work Henderson did on blood and acid-base chemistry. His physiological sensibilities and institutional ties to a medical school gave him ready access to medical data and medical school colleagues (even though his relationship to the medical school was tenuous and fraught with professional tension). His love of French culture and mastery of the French language allowed him to read French scholarship, including Bernard's work and French translation of Pareto's *Trattato*, with ease. Finally, Henderson's institutional location at Harvard gave him a degree of prominence and freedom to explore these ideas at a time when the boundaries between disciplines were still quite flexible. This chapter, then, takes as its starting point the question of how Henderson's unique position made it possible for him to be involved in such a diverse set of pursuits in the early decades of the twentieth century.

Harvard at the turn of the century was a place that was undergoing tremendous institutional change. In his book *Working Knowledge*, historian Joel Isaac carefully describes the world of informal intellectual communities at Harvard, a community that he refers to as the interstitial academy. Isaac defines the interstitial academy as the realm of intellectual engagement that existed between established discipline-based departments or schools.[42] Henderson made expert use of these interstitial spaces to promote his vision of the social sciences and the study of social life. Most importantly, this allowed him ample opportunity to not only transmit, but also refine a systems approach to the study of human relations. This was a vision of social life in which all variables were interconnected, existing in a state of mutual

[42]Joel Isaac, *Working Knowledge: Making the Human Sciences from Parsons to Kuhn*, (Cambridge, MA: Harvard University Press, 2012): 23.

dependence. Henderson therefore stands out, not so much as an idiosyncratic individual, but as someone whose life circumstances and training allowed him to move in and out of these interstitial spaces. His life and work provide us with a comparative lens with which to look at disciplinary border crossing in the early decades of the twentieth century.

This chapter highlights the key turning points in Henderson's life, concentrating on the moments that contributed to his ability to move in and out of different domains of knowledge production. It starts with an overview of his childhood and upbringing with the goal of highlighting the ways in which Henderson was indeed a product of his time. The chapter then considers Henderson's career at Harvard College, Harvard Medical School, and his post-graduate studies. This biographical chapter highlights the ways that Henderson's experiences were both representative of and divergent from the experiences of other scientists of his day. As part of this discussion, the chapter also goes into some detail regarding Henderson's class background. This aspect of Henderson's biography is relevant because it provides a new interpretation of his efforts to establish such institutions as the Society of Fellows and his somewhat unique appreciation of "practical" knowledge and experience. Previous studies have used these examples as evidence of his conservatism. Although there is some evidence that suggests that Henderson held politically conservative views, this chapter aims to give a more balanced account. Indeed, his class background and upbringing suggest that his views might be more in line with liberal and reformist ideals than has been previously considered. This insight is important because it reframes the ways in which Henderson's subsequent work on Pareto should be interpreted and understood within the context of American intellectual history.

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Family Background

Lawrence Joseph Henderson and his twin brother, Clarence Bosworth Henderson, were born on June 3, 1878, in Lynn, Massachusetts.[43] His parents, Joseph Henderson, a native of Salem, Massachusetts, and Mary Reed Bosworth, from Cincinnati, Ohio, with family ties to Massachusetts, happily welcomed their twin sons into their modest home at 37 Nahant Street in Lynn, Massachusetts. That summer, on July 6, 1878, the Henderson home was struck by tragedy. At the age of one month, seven days, young Clarence Henderson died of "debility."[44] Lawrence, also "small and feeble as an infant," barely escaped death. [45] He was likely afflicted with the same illness that took his twin brother's life. In the last decades of the nineteenth century, the infant mortality rate was approximately 16 percent in Massachusetts.[46] The Hendersons and hundreds of other families shared the painful experience of losing a very young child.

Shortly after Clarence's death, the Hendersons relocated to Joseph Henderson's hometown of Salem, Massachusetts. A year-and-a-half after the birth of the twins, Mary Henderson gave birth to a third son, Harry Peters Henderson, in December 1879. A decade later, at the age of thirty-nine, Mary B. Henderson gave birth to her fourth and last child, Robert Graham Henderson in June 1889. All three of the surviving Henderson brothers attended Harvard College.

In the years following Lawrence's birth, Joseph Henderson worked as a commission merchant with strong business ties to the island of St. Pierre. He bought and sold hardware, and

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[43] Massachusetts Vital Records, City of Lynn, MA, 1878, 244.

[44] Massachusetts Vital Records, City of Lynn, 1878, 26. Cause of death recorded as "debility."

[45] W.B. Cannon, "Biographical Memoir of Lawrence Joseph Henderson 1878–1942," *National Academy of Sciences of the United States* 23, (1943): 31–58.

[46] Herbert S. Klein, *A Population History of the United States,* (Cambridge: Cambridge University Press, 2012).

his business enjoyed a period of relative prosperity in the late nineteenth century. In 1893, a year before Lawrence entered Harvard College, Joseph's business was severely affected by the depression of 1893. [47] The Panic of 1893 came at the climax of the struggle over the gold standard and is believed to have resulted from a railroad building "bubble." It gave rise to a 20 percent unemployment rate and a series of bank failures between 1893 and 1897.[48] The fifty-eight-year-old Henderson senior would spend the next decade trying to rebuild his business and doing odd jobs. That business never fully recovered.

Despite the family's precarious financial situation, Joseph did everything he could to support his son's education. In the early years, Henderson attended Salem public schools, graduating from Salem High School in the spring of 1894. His high school transcript reveals that he was a fairly average student in all areas except mathematics and physics.[49] "Mr. L.J. Henderson is a boy of supreme self confidence—with some reason in mathematics and science, to which he takes," said his high school teacher, Mr. C. C. Dodge, in a letter of recommendation for admissions to Harvard College. "He despises the classics as of no value," he went on, "and does poor work in them." With regard to his character, Mr. Dodge had this to say: "Morally his character is good. He will do very good work in the subjects that he likes."[50] A second letter writer, a Mr. Arthur L. Goodrich, Esq., was less generous. Lawrence had worked for Goodrich as

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[47] See Samuel Rezneck, "Unemployment, Unrest, and Relief in the United States during the Depression of 1893–97," *Journal of Political Economy* 61, no. 4 (1953):324–345.

[48] Charles Hoffman, "The Depression of the Nineties," *The Journal of Economic History* 16, no. 2 (1956): 137–164.

[49] Harvard University Archives, Henderson, Lawrence Joseph A.B. 1898, Box 2172 1890–1968, admissions file and grades from high school and college.

[50]Harvard University Archives, Henderson, Lawrence Joseph, A.B. 1898, Box 2172 1890–1968, letter from Mr. C. C. Dodge.

an office assistant. His job was primarily to help Goodrich with basic calculations and bookkeeping. In a short two-sentence letter of recommendation, Mr. Goodrich stated that Lawrence was, "by nature," as opposed to by effort, a young man of more than usual ability. "On nature's kind supply," he continued, "[Lawrence] has lately grown too heavy and become lazy."[51] Despite these relatively lukewarm letters of recommendation, Lawrence was granted admission to Harvard College. In the late nineteenth century, admissions standards differed dramatically from those of today. Lawrence's classmates were primarily from Massachusetts, with a few men from neighboring New England states. In the fall of 1894, Lawrence J. Henderson set off for Harvard College.

Training a Chemist at Harvard, 1894–1898

In the late nineteenth century, those seeking admission to Harvard College were required to take a series of college entrance examinations. These examinations were administered in the summer months of June and September in Cambridge and other select locations. Henderson passed his examinations without much trouble. His results reveal a mild weakness in German language and an above-average grasp of French, Mathematics, and Physics. At the age of sixteen, Lawrence J. Henderson was granted admission to Harvard College and joined the class of 1898. L.J. Henderson took advantage of the opportunity to take intermediate French and enrolled in French 2—reading and composition—with Professor Lewis Sanderson in the fall of his freshman year. He assigned La Fontaine, Corneille, Racine, Moliere, Beaumarchais, Alfred de Musset, and Balzac. The following spring semester Henderson enrolled in French 4—practice in speaking and writing French—an intermediate half-course. By his junior year he was enrolled

[51] Harvard University Archives, Henderson, Lawrence Joseph, A.B. 1898, Box 2172 1890–1968, letter of recommendation from A. L. Goodrich Esq.

in a course listed as being primarily for graduate students, French 15. The theme of the course was French Comedy in the Sixteenth and Seventeenth Centuries, taught by Professor F. Bucher, a Molière expert.

In his later writings and lectures on Pareto and the social system, L.J. Henderson was fond of using examples from Moliére's comedies well as Balzac's *La Comédie Humaine* to illustrate his perception of human nature. Henderson considered Molière to be one of the great diagnosticians of human nature. In the titles of Molière's plays—such as *Le Bourgeois Gentilhomme*, *L'Avare*, *Tartuffe*, and *Le Misanthrope*—Henderson saw the embodiment of uniformities of human character.[52] Moliére and Balzac, L.J. Henderson was fond of stating, best illustrated Pareto's concept of uniformities and persistent aggregates. His strong grasp of the French language would also later enable Henderson to read and comprehend the French translation of Pareto's *Trattato*.

Henderson's transcript shows that he was placed in intermediate mathematics and physics his freshman year; by the end of his sophomore year, he had completed all of his college training in both.[53] In the fall of his sophomore year he enrolled in his first chemistry course, Chemistry 1—a laboratory-based course on general descriptive chemistry. The course was taught by the prominent organic chemist Charles Loring Jackson. In his remaining two years at Harvard College, Henderson continued to take increasingly advanced coursework in both Chemistry and French.

The Hendersons' financial situation stabilized somewhat in the 1894, as they seem to have been able to pay for their son's education for the 1894–1895 academic year. The cost of

[52] Lawrence J. Henderson, "Sociology 23," (1938): 30.

[53] Henderson's student records for the academic year 1894–95 show that he received a 'B' in both French 2 and Math F. That same year he took introductory German, German A and received a 'C-' in that course.

tuition at Harvard College was $150.00 in 1894, the year Lawrence J. Henderson enrolled.[54] The total cost of attendance—including room, board, club fees, utilities, and sundries—could range anywhere between $372—on the low end—and $1,010—on the high end.[55] Modest fees by today's standards, but nonetheless a considerable sum for most middle-income families in the late nineteenth century. That first year, the family was able to cover the full cost of his freshman expenses.

The second year, however, Joseph found himself struggling to come up with the necessary funds. Joseph submitted an application for a scholarship in the spring of 1895, to defray the cost of his eldest son attending the College for the 1895–1896 academic year. Joseph reported his estimated household income to be $2000.00, $400.00 of which was to be set aside specifically to pay for L.J. Henderson's education during his sophomore year.[56] The remainder was to be spent on supporting his other two children, ages fifteen and six, and his wife. The scholarship application indicates that L.J. Henderson's intended plan after graduation was to study medicine. Unfortunately, he had no special claim to any of the available scholarships other than a "decrease in parent's income."[57] His application was denied. A generous aunt stepped in to donate $100 toward L.J.'s education.[58]

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[54] $150 is approximately equal to $3,878 when adjusting for inflation.

[55] Approximately equal to $9,672 to $26,260 when adjusting for inflation.

[56] This annual income comes to approximately $52,000 when adjusting for inflation. The amount set aside for college fees comes to approximately $10,400 (making up 20 percent of the household income). Harvard University Archives, Box 2172 1890–1868, Henderson, Lawrence Joseph A.B. 1898, application for scholarship dated May 28, 1895.

[57] Ibid.

[58] This comes to approximately $2600.00 when adjusting for inflation.

The next year, the family's financial situation had declined further. The scholarship committee awarded L.J. Henderson a Price Greenleaf Scholarship for the sum of $100.00 to cover the cost of attendance for the 1896–1897 academic year. [59] Toward the end of Henderson's junior year, on April 26, 1897, Joseph Henderson submitted a third scholarship application. That year the family finances would be stretched even further, as L. J.'s younger brother Harry was expected to enter the College in the fall of 1897. The scholarship committee awarded L.J. Henderson the Browne Scholarship for the sum of $100 for the 1897–1898 academic year. [60] At the time, the bulk of financial aid came in the form of restricted funds to support specific groups of students according to the funders' wishes.

It was during this same year that Henderson began working as a research assistant to Professor Theodore W. Richards in the Chemistry department. It was here that Henderson really began to shine. His junior year transcript reveals that he enrolled in nearly every advanced chemistry course available to him that year.[61] He concurrently enrolled in Chemistry 3—a laboratory-based qualitative analysis class taught by professors H.B. Hill and Messrs. Sylvester, Soch, Holmes, and Dow—and Chemistry 4—a laboratory-based quantitative analysis course with T.W. Richards, an up-and-coming professor. He performed well above average in both. The subsequent semester he enrolled in Richard's famous Chemistry 8—History of Chemistry and Chemical Philosophy. The course was required to graduate with final honors in Chemistry.

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[59] Harvard University Archives, Endowment Funds of Harvard University, June 30, 1995, p. 31.

[60] Although L.J. Henderson has been depicted as a typical New England Brahmin, his numerous attempts to secure financial aid to finance his education paint a different portrait of Henderson's financial situation as a young student.

[61] Harvard University Archives, Box 2172, 1890–1968, Henderson, Lawrence Joseph A.B. 1898.

Richard's course instilled in Henderson a lifelong passion for the history and philosophy of science.

In the fall of his senior year, Henderson also secured an assistantship in Richard's laboratory. His paid assistantship was an acknowledgement of Henderson's natural aptitude in chemistry and his evolving intellectual friendship with Richards. His first scientific publication was a product of his laboratory research in Richards' lab.[62] Henderson continued to work in Richards' laboratory while a medical student at Harvard Medical School. He also worked as a teaching assistant during these years to help cover some of his living expenses. Given the family's financial woes, the assistantship could not have come at a better time.

Soon after enrolling in Chemistry 8 with Richards, Henderson joined the Boylston Club—one among at least a dozen undergraduate clubs dedicated to fostering community. The Boylston club began as an organization that discussed recent developments in chemical science and often invited guest lecturers from both the faculty and local industries to their meetings. In December 1893 the members recommended that there be more social meetings. Up until this point, the meetings had been primarily business-oriented and limited to the executive committee. Initially, discussions were open only to a small subset of members. Lectures were generally open to students interested in chemistry and the chemical sciences. The club was an exciting and growing group dedicated to expanding students' knowledge of chemistry and exposing them to cutting-edge research conducted within the university and in industry. Guest speakers throughout the '90s covered topics that were both relevant to various local industries and innovative in themselves: the dissociation theory, the theory of isomorphism, methods of qualitative analysis of foods, and Mendeleev's Classification scheme. The Club also hosted field trips to such

[62] Lawrence J. Henderson, C. Gordon and W. L. Harrington, "Natriumchloride und Kadmiumsulfat," *Ztschr. Phys. Client*, 27, (1898): 425.

companies as the Lora Art Tile Works in Chelsea, Massachusetts, and the Cochran Chemical Works in Everett.

On February 23, 1897, in the spring semester of his junior year, Henderson's name was proposed for membership. He was admitted with seven other applicants in March. The themes discussed must have left a very strong impression on young Henderson, as he would later go on to tackle several of the topics covered at Club meetings. In fact, the problem of dissociation would serve as the topic of his undergraduate honors thesis in chemistry. Henderson became increasingly interested in one of the key problems facing chemists and physiologists at the time: the regulation of acidity in the human organism. Little was known about the body's chemistry at the time; even the idea that the body's internal environment is maintained at nearly neutral pH was unknown at the time that Henderson was a student. Although Henderson's membership was short, spanning from the spring semester of his junior year to the spring semester of his senior year, it is clear that the questions he was asking about the nature of inorganic matter, specifically as they relate to acid-basic chemistry, were of major interest beyond his own studies. The problems that L.J. Henderson tackled as a young chemist and physiologist were problems that captured the attention of a whole generation of physiologists.[63]

Henderson's junior year appears to have been an intellectually defining one for the young scientist. It was during this year that he began to form his identity as a chemist with a broad range of interests in philosophy as well as the various biological, medical, and industrial

[63] For a first-person account of the problem of blood physiology—mainly the development of a full picture of blood as a functioning system perfectly adapted to support mammalian life on earth—and how it captured the attention of an entire generation of biological chemists and physiologists, see John T. Edsall, "Blood and Hemoglobin: The Evolution of Knowledge of Functional Adaptation in a Biochemical System. Part I: The Adaptation of Chemical Structure to Function in Hemoglobin," *Journal of the History of Biology* 5, no. 2 (1972): 205–257. Similarly, for an overview of the centrality of the theory of dissociation, ionization, and acid-base equilibrium in the history and development of chemistry and its relationship to medicine see Harold M. Malkin, "Concept of Acid-Base Balance in Medicine," *Annals of Clinical & Laboratory Science* 33, no. 2 (2003): 337–345.

applications of chemistry. His interest in the intersection of fields was explored at length in his senior thesis (discussed later in this chapter). In addition to his growing interest in chemistry, Henderson also enrolled in Economics 1, a course taught by Professor Frank William Taussig. The course covered the principles of political economy and consisted of lectures on economic development, social questions pertaining to economic change, and financial legislation. It was here that Henderson first encountered the works of mathematical economist, and father of general equilibrium in economics, Léon Walras, neo-classical economist and former student of Willard Gibbs, Irving Fisher, and Adam Smith. Henderson would go on to both utilize and criticize the works of economists in his writings for their over-reliance on the assumption that individuals act according to the rules of logic as opposed to sentiments.

Henderson's senior year began on September 30, 1897. His transcript shows that he took a substantially reduced course load during his final year at the College. He enrolled in English 8—an English literature course—and Fine Arts 3. Fine Arts 3 was a course on ancient art that covered everything from classical philology and German religious painting and scripture to architecture.

The summer before his senior year, L.J. Henderson had dedicated himself to writing an essay on Arrhenius' theory of electrolytic dissociation for which he was awarded the prestigious Bowdoin Prize in the fall of his senior year. The essay, titled "The Hypothesis of Electrolytic Dissociation," demonstrated his mastery of dissociation theory and the fundamentals of physical chemistry. In this essay he also explored his interest in interdisciplinary work. In the opening paragraph, he states that physical chemistry emerged from the borderland between physics and chemistry: "chemistry and physics developed and expanded toward each other. At first they were distinct and then they began to overlap." "Of late," he went on, "both chemistry and physics have

seen in this border land between the two sciences allying possibilities of new knowledge and conception of nature, and so it is being studied with care."[64] For L.J. Henderson, the most obvious point of contact between the two sciences—chemistry and physics—was the study of electrolysis. Electrolysis was, in L.J. Henderson's opinion, "the inauguration of physical chemistry."

Incorporating lessons from Chemistry 8 on the history and philosophy of chemistry, L.J. Henderson presented a brief history of the development of electrolytic process, starting in 1805 with Srothuse's hypothesis—which posits that opposite charges would dissociate but gives no account of where the energy comes from—and ending with Arrhenius' 1887 paper on the theory of electrolytic dissociation. Perhaps the essay's most original contribution is its demonstration of how Arrhenius' theory of dissociation is consistent with ordinary laws of chemical mass action and equilibrium.[65] When one applies the law of mass action to the study of salt solutions, Henderson concluded, the hypothesis of electrolytic dissociation becomes "an important necessity." He goes on to state, "No stronger evidence can be given of a theory than that it is in harmonious relation with our other ideas." This he believed was the "strongest demonstration of the usefulness and consistency of a theory in establishing its truth." Henderson believed that the fundamental principles of science were "interwoven; and the theory of Arrhenius has certainly shown some of the relations which were before hidden." His essay on electrolytic dissociation marks his first attempt to formally write down his growing interest in the interdependency of

[64] Harvard University Archives, call number 89.165.620, Bowdoin Prize, Submitted November 1, 1897, "The Hypothesis of Electrolytic Dissociation."

[65] For a brief history of the development of chemical equilibrium and mass action see, Sol W. Weller, "Napoleon Bonaparte, French Scientists, Chemical Equilibrium, and Mass Action," *Bulletin for the History of Chemistry* 24 (1999): 61–66.

variables and equilibrium. He spent the next decade investigating the dynamics and implications of electrolytic dissociation in inorganic and organic systems.

L.J. Henderson was fortunate to have come of age as a scientist during a period of exciting change within the established disciplines of chemistry and physics. As he wrote in his essay on Arrhenius, the field of physical chemistry was becoming increasingly well established as its own subfield within chemistry. The new frontier within his grasp was biology. Henderson would later describe biology as "the most progressive science" and the "science of the future."[66] He would go on to make important contributions at the intersection of the physical sciences and biology. He considered this to be the area with the broadest potential for scientific development.

Becoming a medical scientist, 1898–1904

L.J. Henderson had, at the start of his sophomore year, dedicated himself to pursuing medicine upon completion of his undergraduate education. He was admitted to Harvard Medical School in 1898 and he continued to work in T.W. Richards Laboratory with a great deal of independence. He devoted himself primarily to his own researches and took the bare minimum number of courses required of him at the medical school. His goal was to develop himself into a biological chemist, and at the time the only way to prepare oneself for a career as a biological chemist was to attend medical school.[67]

[66] Harvard University Archives, Notes in History of Science I, 1913–1914, Call No. HUC8913.3.39.1.

[67] Robert Kohler, *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline*, (Cambridge, Cambridge University Press, 1982). For an overview of the history of biochemistry and its historiography see Robert E. Kohler, "The History of Biochemistry: A Survey," *Journal of the History of Biology* 8, no. 2 (1975): 275–318.

Henderson attended medical school during a period which has been described as the "The Innovative Period" in medical education by historian of medicine Kenneth M. Ludmerer.[68] This period was characterized by important changes in curriculum, newly established entrance requirements, the proliferation of new scientific subjects being taught at the medical school, and the introduction of new methods by which medicine was taught. This new pedagogic style required the student to take an active role in his education rather than simply play the role of passive observer. This shift is best illustrated by the introduction of what has been called the laboratory and clinical clerkship. These changes also took place against a shift in medicine from a strongly French-oriented clinically based practice to a more German style of teaching medicine. This new German-oriented medicine stressed the importance of laboratory instruction and the clinical clerkship. Ludmerer documents a series of changes in the mid- to late nineteenth century that start with the rise of German medical science and the emergence of an academic elite and ends with the spread of reform across American medical schools, culminating in the Flexner report in 1910.

In many ways this account of the changes in medical education corresponds well with L.J. Henderson's experience. He attended medical school at a time when more and more of the medical elite welcomed the incorporation of the basic sciences into the medical school curriculum. As historian John Harley Warner has demonstrated, however, this change was gradual and not without resistance. Warner shows the many ways in which French medical ideals and practices remained one of the most intellectually powerful sources of change that reshaped American conceptions of scientific medicine through the final third of the nineteenth century. [69]

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[68] Kenneth M. Ludmerer, *Learning to Heal: The Development of American Medical Education,* (New York: Basic Books, 1985), 47–71.

[69] John Harley Warner, *Against the Spirit of System*, (Princeton, NJ: Princeton University Press, 1998), 4.

Warner argues that the growing popularity of Germany as a site for post-graduate medical education had less to do with the "intellectual stagnancy of the Paris School," and more to do with access to experiential knowledge.[70] It was within this context that Henderson came to define himself as a chemist and physiologist.

In the year that L.J. Henderson embarked on his medical studies, the Harvard Medical School had made the four years' course of study mandatory. This requirement had been established as early as the fall of 1892. Beginning in the fall of 1899 a new arrangement of subjects taught in the first two years had been established. In the first year, students were required to devote their time entirely to anatomy and the "correlated" subjects of histology and embryology. During the second half of the first year, students would be expected to take physiology and physiological chemistry. The first half of the second year was to be devoted to pathology and bacteriology and the remainder of the second year to clinical chemistry, materia medica and therapeutics. Students had the option of taking additional courses in pathology, theory and practice, clinical medicine, surgery, and clinical surgery. In the third year of study, students were to devote themselves to theory and practice in one of the specialties—pediatrics, surgery, obstetrics, gynecology, dermatology, neurology, or psychiatry. The fourth year was again focused on clinical medicine, with the option of exploring additional specialties such as legal medicine, ophthalmology, or orthopedics. What is notable about the period of Henderson's medical education is that the word "experiment" had entered the course catalogue. In fact, starting in 1898, Harvard began requiring all of its first-year medical students to take a laboratory course in experimental physiology.[71] What was once optional eventually became an integral part

[70] Ibid., 8.

[71] John Harley Warner, "Physiology," in *The Education of American Physicians: Historical Essays*, Ronald L. Numbers, ed., (Berkeley: University of California Press, 1980): 48–71.

of the medical school curriculum at America's best schools. In order to ensure that their students had access to patients, Harvard Medical School secured partnerships with local hospitals.[72]

L.J. Henderson never took to the clinical side of medicine. Years later he would candidly remark to his friend and colleague Walter B. Cannon, "No one but myself knows how incompetent I am in the clinical aspect of the matter, and in dealing with the actual living organism even in a physiologist's way."[73] He was always quick to acknowledge his own lack of clinical knowledge and experience. It was his lack of clinical knowledge that drove him to partner with experienced clinicians such as Walter Palmer, a young physician associated with Massachusetts General Hospital. This lack of experience would eventually become a source of tension between Henderson and his colleagues. Although he spent many years teaching at the medical school and collaborating with physicians, his lack of clinical experience made him an outsider. For a man who wrote so much about the importance of practice, he practiced very little in the fields he influenced the most.

For Henderson, medical school was a necessary passage point, a means to an end. His focus was primarily on research at the intersection of chemistry and biology. Despite his relative lack of interest in practicing medicine, his years at the medical school helped him make contacts with key individuals in the field. He would later, upon completion of his post-graduate studies, serve as an instructor at the medical school. He also maintained ties to medical school faculty throughout his career.

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[72] The hospitals included are: Boston City Hospital, Boston Dispensary, Boston Insane Hospital (also known as Pierce and Austin Farms), Children's Hospital, Massachusetts Charitable Eye and Ear Infirmary, Harvard Medical School, Infant's Hospital, McLean Hospital, Massachusetts General Hospital.

[73] Harvard Business School Lawrence J. Henderson papers, Carton 01, Folder 1, Cannon, Walter B. 1917–1937, letter dated April 1917.

Upon completion of his medical studies, Henderson joined the famous laboratory of Franz Hofmeister at the University of Strasbourg from 1902 to 1904.[74] His interest in electrolytic dissociation and the impact of salts on the properties of solutions continued. Hofmeister had been studying the effect of salts on physical properties of protein solutions—i.e. viscosity and osmotic pressure—since 1887.[75] Reflecting on Henderson's experience abroad, W.B. Cannon remarked, "There is some question as to whether [Henderson] received any formal advantage from his experiences there; an associate has testified that he was prone to wander about the laboratory and converse and theorize with other advanced students, especially concerning the methods they were using and the results they were obtaining."[76] The implication being that, though he did not produce anything of significance during this period, he profited from the work of others. He joined the lab primarily in an effort to get a solid foundation in biological chemistry and its methods. He went to Strasbourg with a solid understanding of ionization and dissociation and the potential implications of these phenomena for the regulation of physiological processes—mainly the regulation of acidity in the organism. What we do know is that he came out of this experience a changed man. He had, in the two years from 1902–1904, established lifelong friendships.

His experience in Strasbourg sharpened his political awareness—in particular the political history of Alsace, which had been passed from France to Germany after the war of

[74] At the time, the University of Strasbourg was in German territory. In 1918 Alsace-Lorraine was returned to France. When Henderson was there, the university was dominated by German professors and students.

[75] For an historical overview of Franz Hofmeister's scientific contributions within the broader context of German biological chemistry see Joseph S. Fruton, "Contrast in Scientific Style. Emil Fischer and Franz Hofmeister: Their Research Groups and Theory of Protein Structure," *Proceedings of the American Philosophical Society* 129, no. 4 (1985): 313–370.

[76] Walter B. Cannon, "Lawrence Joseph Henderson, 1878-1942," *Biographical Memoirs of the National Academy of Sciences* 23 (1943): 33.

1870.[77] In the years after the handover, no one could ignore the political and social tensions between French and Germans living in the Alsace-Lorraine area where the University was located. His love of French culture and literature was reinforced, and he left Alsace an intense Francophile with a genuine distrust of all things German. His closest friends and colleagues—including Franz Luoop, Gustav Embden, and Karl Spiro—went on to become leaders in German biochemistry. Years later, when the First World War was nearing its end, Henderson offered his services to friends who had been stationed abroad. In a letter to Carl Alsberg, Henderson suggested that he be sent to Alsace "as a kind of intelligence officer or advisor with respect to problems affecting the population." He reminded his friend that he was fluent in French and that after having spent two years at the University of Strasbourg he was on friendly terms with a number of "French men of some importance including Henri Lichtenberger, one of the most important Parisians of Alsatian origin." He felt strongly that this knowledge of "the problem and the people" of Alsace would help to reestablish civil order.[78] It was also during this time that he established his lifelong friendship with the young biological chemist Carl Alsberg.

Henderson's publication record suggests that he obtained more than just social experience in Strasbourg. In a paper titled "The Physical Chemistry of Milk" published during his time abroad, Henderson demonstrated that one could measure the molecular concentration of milk using its conductivity. This was a proof-of-concept paper. The goal was to show that a very similar method could be used with other solutions—mainly molecular concentration in renal secretion that could later be used for diagnostic purposes.[79] In addition, his work with Karl Spiro

[77] HUA, L.J. Henderson Papers, "Memories," MS, 1936-1939.

[78] Harvard Business School, Lawrence J Henderson papers, Carton 01, Folder 5, Alsberg, Julius and Carl.

[79] Lawrence J. Henderson, "The Physical Chemistry of Milk," *Journal of Medical Research* 10, no.1, (1903): 127–131.

suggests that he was at the very least partially active during his years abroad. In his book *Blood*, he describes in great detail a series of experiments conducted in collaboration with Spiro—a senior scientist at the University of Strasbourg.[80] In collaboration with Spiro, Henderson investigated the ionization constants of beta-oxybutyric acid and acetoacetic acid, which was used to show how that the kidney is an important means of defense against acid intoxication in diabetes.[81] In another published study the two men investigated the physico-chemical basis of the variation in distribution of inorganic material between blood plasma and red cells under the influence of carbonic acid.[82] In short, this period of his life was far from a casual waste of time; it was a period that both reinforced his interest in the emergent field of biological chemistry and expanded his vision of the broad-ranging biological implications of the physical properties of inorganic compounds. He went on to explore this topic in great breadth and depth in his first published book, *The Fitness of the Environment* (1913), which is the subject of chapter two.

Navigating Administrative Waters: Between the Medical School and the College

After completing his post-graduate studies at the University of Strasbourg, L.J. Henderson returned to the Harvard Medical School as a lecturer in biological chemistry in the department of physical and pathological chemistry. With the exception of a few years visiting other universities, L.J. Henderson made Harvard his professional home from 1904 until his death

[80] Henderson, *Blood*, 92.

[81] L.J. Henderson and Karl Spiro, "Zur Kenntnis des lonengleichgewichts im Organismus. I. Teil. Ueber Basen und Sauregleichgewicht in Harn," *Biochcm. Ztschr* 15, (1908): 105–113. In addition to the joint publications with Spiro, Henderson dedicates the German translation of *The Fitness of the Environment* I *Die Umwelt des Lebens. Eine physikalischchemische Untersuchung über die Eignung des Anorganischen für die Bedürfnisse des Organischen*) to Karl Spiro. The dedication suggests a debt of gratitude to his German colleague.

[82] L.J. Henderson and Karl Spiro, "Zur Kenntnis," *Kolloid Zeitschrift III* 91, (1908): 114–122.

in 1942. Towards the end of his career he became increasingly interested in social theory and began using his leadership at the Harvard Fatigue Laboratory to try out some of his ideas. After several decades studying physiological regulation, Henderson became interested in social regulation and stability. The following section traces Henderson's path from a young professor at Harvard Medical School to his increasing engagement with social theory.

Just as he had in his undergraduate and medical school years, Henderson joined the laboratory of T.W. Richards while he simultaneously pursued a career as a professor at the Harvard Medical School. His first research project was an empirical study on the heats of combustion of organic molecules in relation to their structure.[83] A year later he was promoted to instructor of Biological Chemistry at the Harvard Medical School, a rank he held until 1910. The Medical School, however, had only recently incorporated instruction in biological chemistry into its curriculum.

Prior to 1904, the teaching of chemistry at the Medical School consisted primarily of problems of toxicology, the purity of the water supply, and analysis of urine.[84] Walter B. Cannon's biographers note that, early in the twentieth century, Cannon did everything within his power to encourage the formation of an independent biological chemistry department at the medical school. "There is no doubt," he wrote in a letter to President Eliot, "that the most promising field for the future development of medical science is the field of chemical physiology."[85] Within this context of change and excitement, Henderson's background and

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[83] Lawrence J. Henderson, "The Heats of Combustion of Atoms and Molecules," *Phys. Chem.* 9, (1905): 40.

[84] Saul Benison, A. Clifford Barger, and Elin L. Wolfe, *Walter B. Cannon: The Life and Times of a Young Scientist*, (Cambridge: Harvard University Press, 1987): 124.

[85] Ibid., 124.

mastery of physical chemistry and its biological implications might have lead to a successful career in the medical school. Some of his colleagues, however, harbored hostility toward his seeming lack of interest in first-year medical students and his lack of experience in the clinic.

One of Henderson's most vocal opponents was Otto Folin, a research chemist at McLean Hospital. Henderson and Folin experienced growing tension over their divergent views of the acidity of urine. In a paper published in 1906, L.J. Henderson directly discredited Folin's work on phosphate equilibrium in urine, stating that Folin's argument that urine contains no disodium phosphate because it does not precipitate upon addition of calcium chloride is "fallacious."[86] In this paper, Henderson systematically marshals empirical data in support of his view that "in urine there exists a mixture of mono- and di-hydrogen phosphates of sodium, ammonium, and other bases."[87] The paper publically points out Folin's deficiencies in the area of chemical equilibrium—especially in relationship to animal fluids. His subsequent work only intensified the feud between the two men.

What was at stake for Henderson in this debate was the idea that physico-chemical "habits of thought" and methods were important for the study and practice biochemistry. Henderson's paper demonstrated that one could use analytical methods to quantify the degree of hydrolysis, ionization and concentration of substances in urine. He uses empirical evidence to argue that Folin's method, which was largely qualitative, was unable to analyze the conditions of equilibrium in body fluids accurately. In a series of charts and graphs, Henderson shows that if temperature is not fixed, errors of at least five percent may be readily obtained; this was

[86] Lawrence J. Henderson, "Equilibrium in Solution of Phosphates," *Am. J. Phys.* 15, no. 257 (1906): 270.

[87] Ibid.

especially true, he argued, "when Folin's improved method is employed."[88] Henderson's experiments attempted to create conditions in the laboratory closely resembling physiological conditions.

Henderson also put forward a view of the body as self-regulating. He pointed out that a series of studies had shown that living cells possess an efficient mechanism to prevent considerable hydrogen or hydroxyl ionization. In other words, Henderson argued that excessive amounts of mono- or di-sodium phosphate might be added to the system without causing even faint acidity or alkalinity.[89] At issue was the most appropriate way to study the biochemistry of the body, as well as a view of the body as a self-regulating system at the cellular and biochemical scale. Although Henderson succeeded in showing the very real limitations in Folin's paper, his efforts did not translate into professional recognition at the Medical School. In 1905 when the chairman of chemistry at the Harvard Medical School died, L.J. Henderson's name was quickly passed over as a potential replacement. Instead, Otto Folin was selected to take up the post.

In 1906, the department of Biological Chemistry at Harvard Medical School was moved from physical and pathological chemistry to the department of comparative physiology. In 1906 Henderson was joined by his former colleague from his Strasbourg years, Carl Alsberg. The two men, along with Otis F. Black—another of L.J. Henderson's collaborators—and Francis H. McCrudden, taught the lecture and laboratory component of biological chemistry to first-year medical students. Soon Henderson was given additional responsibilities. In 1907, he began teaching graduate courses on the applications of physical chemistry to biology. He lectured five times a week during the January term. The course, biochemistry 4, was an introduction to recent

[88] Ibid., 266.

[89] Ibid., 268.

applications of physico-chemical theories and methods in biology and medical science. Topics covered included the theory of solution, concentration law, catalysis, ionization, the theory of colloids, and the physico-chemical organization of the cell—all topics in which L.J. Henderson had developed expertise.

That same year, Henderson inquired about his prospects at the Medical School. President Eliot told him in few words that his future at the medical school was far from secure.[90] That same year, his friend and colleague Carl Alsberg abruptly resigned after being denied promotion.[91] The mixture of hostility and indifference with which L.J. Henderson was received at the Medical School, despite his evidence expertise, gives us some indication of the enduring tensions between laboratory and clinic in the first decade of the twentieth century. Having had no clinical experience, L.J. Henderson was regarded with some suspicion as a perpetual outsider. His highly quantitative publications on acid-base equilibrium likely further alienated his colleagues at the medical school.

According to some of his contemporary, these tensions stemmed from Henderson's own natural tendency to provoke. In a biographical essay about Henderson, Cannon wrote that the scientist "enjoyed argument and often deliberately employed dogmatic statements in order to shock" listeners into reexamining their opinions.[92] At the weekly meetings of the Society of Fellows, Henderson was fond of holding court. As Cannon recounts, Henderson would regularly expound his views, "often overwhelming his opponents by sheer force."[93] Perhaps most

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[90] Benison, Barger, and Wolfe, *W. B. Canon*, 127.

[91] Ibid.

[92] Cannon, "Lawrence J. Henderson," 49.

[93] Ibid.

importantly, he was regarded as "an extreme conservative."[94] Others took this conservatism to stem from a general distrust of "rulers, the time-serving politicians."[95] His friend Arlie V. Bock, a physiologist, wrote that Henderson "distrusted many current visionary schemes of a social nature" and favored "old-fashioned routines upon which our society has been built, now too often lightly regarded by reformers."[96] This orientation towards society is clearly reflected in his embrace of equilibrium theory and its implications for social stability, as well as in his very explicit distrust of the reform-oriented politics of the first half of the twentieth century. Despite his gruff public image, Henderson had a warmer side—one that, Bock recalls, was "too often hidden from his more learned friends."[97]

Despite all of this professional turmoil, Henderson's research began to take off in the Laboratory of Biological Chemistry at the Harvard Medical School. These were years of profound productivity. In 1908 he made what would be his major contribution to our understanding of the balance between acids and basis in animal organisms, including the process whereby the organism maintains itself at the point of neutrality.[98] He states in the opening paragraph of this groundbreaking paper that the theory was the result of the "last three years" of laboratory work "concerning equilibria of neutrality."[99] Henderson had discovered the capacity

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[94] Ibid.

[95] Arlie V. Bock, "Lawrence Joseph Henderson, 1878–1942," *Transactions of the Association of American Physicians* 57, (1942): 17–19.

[96] Ibid., 17.

[97] Ibid., 19.

[98] Lawrence J. Henderson, "The Theory of Neutrality Regulation in the Animal Organism," *Am. J. Phys.* 21, (1908): 427. There were a series of other publications relating to the same topic, but this particular paper summarizes the research he had done on the topic up until this point. For a more extensive bibliography see Cannon, "Lawrence J. Henderson".

[99] Henderson, "The Theory of Neutrality," 427.

of carbonic acid to preserve neutrality in aqueous solutions that contained the bicarbonate. In this paper he proposed the equilibrium expression for which he most commonly remembered, $K = [H^+][HCO_3^-]/[dCO_2]$.[100] Henderson began to zero in specifically on the unique properties of carbonic acid and the role of the carbonic acid buffer system in stabilizing hydrogen ion concentration in living systems as well as the ocean.

The year after the publication of this groundbreaking paper, Henderson joined forces with Edward E. Southard, a well-respected professor of neuropathology, to publish a paper in *The Harvard Bulletin* proposing reforms in medical education. This work, titled, "Education in Medicine: The Relations of the Medical School and the College," caused heated debate among the Medical School faculty. The authors wrote, "qualitative improvement in medical education is far more desirable than those forms of quantitative alteration now going on, far more desirable than either cramming or lengthening the curriculum."[101] Like other reformers of his day, Henderson was interested in refining the curriculum to "strengthen rather than lengthen the medical curriculum."[102] What should be the place of medical sciences in the collegiate department of the university, the authors asked? Why, in the case of Harvard, were they not found there? Moreover, they noted, Harvard Medical School, "has to a degree been sequestered rather than assimilated by Harvard University."

Henderson's and Southard's main critique was that the so-called medical courses of the laboratory type were essentially courses in natural science; they were only medical in so far as

[100] K = equilibrium constant.

[101] L. J. Henderson and E. E. Southard, "Education in Medicine: The Relations of the Medical School and the College," *The Harvard Bulletin* 12, no. 5 (1909): 2.

[102] Ibid., 2.

they are also indispensible to the art of medicine.[103] The medical school needed a clear union with the teaching of the natural sciences in other parts of the University and College. This long-standing division was not for "logical reasons, but for historical ones." For this reason, the two men argued, the medical sciences should be opened up to the entire university and the courses taken should count toward the A.B. degree. Henderson and Southard believed that such courses as physiology could be of great value to general education. They specifically proposed that the Faculty of Arts and Sciences should be allowed to examine the science courses taught at the medical school and to include the ones found suitable in the approved choice of electives.

The two authors noted that such a change would bring multiple benefits. First, it would allow the medical school to "articulate with the whole American University System."[104] A closer union with the university "system" as a whole, they thought, would only strengthen the medical school and the quality of training received by medical students. This change would also serve to increase the geographic diversity of the student body by removing barriers to entry by students with bachelor's degrees from other universities, where they had been allowed to enroll in so-called medical sciences. Students arriving from midwestern colleges and universities often held what was called a "combined A.B.," which included basic courses in the natural sciences in the first year and strictly medical science courses in the second. These students had chosen this path with the goal of pursuing a medical career. According to Harvard Medical School's existing admissions criteria, those students holding a combined A.B. would have to re-take those courses. As the authors point out, this made attendance at HMS either impossible or unnecessarily costly for many students coming in from the West. A third benefit of opening up these courses to the College would be that it would allow students who did plan to pursue a career in medicine the

[103] Ibid., 3.

[104] Ibid.

benefit of taking medical science courses. Henderson and Southard believed that this would offer a tremendous advantage to both the individual student and society, as nearly all students would benefit from a basic understanding of the medical sciences. Finally, Henderson and Southard suggested that their proposed changes might help break down what they saw as an overly rigid curriculum. They advocated for greater freedom of choice at the medical school—something akin to what had already developed in medical departments in European universities and American graduate schools. What they envisaged for the medical school was a more flexible curriculum "with no regular prescribed course of study."[105]

At stake in their proposal was a bigger question about the relationship between the medical school and the Faculty of Arts and Sciences.[106] We can see, imbedded within the proposal, a growing recognition of the shifting lines demarcating the boundary between medicine and science. Similar debates were happening at Yale, Johns Hopkins, and the University of Pennsylvania throughout the first decades of the twentieth century. Admissions and graduate requirements were in flux, with consequences for pre-medical and medical school curricula and medical practice.

Among the many aspects touched on in the Southard and Henderson article, the argument for formalizing a pre-medical science undergraduate curriculum proved to be the most controversial. Perhaps in anticipation of the criticism, W.B. Cannon anonymously published a paper in support of the proposal.[107] Cannon's anonymous essay, however, could not prevent the

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[105] Ibid.

[106] The Division of Medical Sciences was established in Harvard's Graduate School of Arts and Sciences in 1908 to provide students with broad training in biomedical scientific research.

[107] Walter B. Cannon, "The Relations of the Medical School," *Boston Medical and Surgical Journal* 161, no. 22 (1909): 790–791.

appearance of a scathing review by George V. N. Dearborn appearing in the *Harvard Bulletin* on November 3, 1909.[108] Dearborn was at the time a professor of physiology at Tufts Medical School. He saw Henderson's and Southard's plan as an unwarranted attack against the education of the general practitioner. He felt strongly that the adoption of such a plan would lead to the preparation of medical scientists and specialists rather than well-rounded general practitioners. A few weeks later, Henderson and Southard responded to Dearborn's critiques. Henderson and Southard argued that Dearborn "has been aiming, not at us, but at a phantom of his own imagining."[109] In an effort to counter Dearborn's claims that their plan would produce specialized M.D.'s akin to the expert Ph.D., the authors reiterated, "No one, certainly not we, has for an instant thought of relaxing the requirements for the M.D., nor has it been suggested, and assuredly it shall not be suggested by us, that any of the important subjects of the medial curriculum be omitted from anybody's medical education."[110] Instead the authors proposed that the rigidity of the medical curriculum should be relaxed and that students should be subjected to written, oral, and practical assessments similar to those required of the Ph.D. Henderson and Southard further argued that Professor Dearborn's fear of their plan was "grounded on his belief that we were turning away from the ideal of developing practitioners."[111] Another critic was

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[108] Walter F. Dearborn, "Education in Medicine," *Harvard Bulletin*, 12, no. 7 (1909).

[109]The editors of the *Boston Medical and Surgical Journal* published a second response to Dearborn's critique of Henderson and Southard on December 23, 1909. In the editorial they recanted previous support for the Henderson and Southard proposal. This time they tempered their enthusiasm by qualifying their support for the proposal and arguing that change was indeed needed, but that it ought to be implemented incrementally, see Henderson and Southard, "The Medical School and the College," *Boston Medical and Surgical Journal*, 161, no. 24, (1909): 865–866. A few weeks after Dearborn's essay appeared, Henderson and Southard published a response to his critiques and to the editorial staff see, Henderson and Southard, "Education in Medicine," *Boston Medical and Surgical Journal* 161, no. 26 (1909): 948–949.

[110] Southard and Henderson, "Education in Medicine," 865.

[111] Ibid.

Thomas Dwight, a prominent anatomist and senior member of the Harvard medical faculty. Dwight's disagreement went to the very heart of Henderson and Southard's proposal. He took issue with the claim that one could draw a sharp distinction between laboratory and clinical courses, Southard and Henderson had suggested. The two had stated that laboratory courses of general importance to the natural scientist and medical man align, while the clinical courses were intended to specifically teach the application of science and the art of medicine. Laboratory courses should, therefore, be open to all students at the college, while clinical courses would only be useful to those planning on practicing medicine. Dwight felt that this distinction was meaningless and that the primary purpose of *all* courses taught at the medical school was to prepare students to practice medicine.[112]

The degree to which the Medical School should integrate itself into the rest of Harvard was a topic of ongoing debate in the first decade of the twentieth century. This model of a fully integrated medical school is commonly referred to as the "Flexner Model."[113] The separation between undergraduate and professional education was an American phenomenon. In European universities, medicine was also an undergraduate discipline, and students were permitted to study medicine upon entering university. In the United Sates, in contrast, medicine was strictly a graduate discipline with its own standards for admissions and a separate curriculum.[114] In the United States, most schools did not require a baccalaureate degree for admission to medical school. The one exception to this was Johns Hopkins Medical School, which was held up by reformers as the model of the future. After the publication of the Flexner report in 1910, pressure

[112] Benison, Barger, and Wolfe, *W. B. Canon*, 231.

[113] Robert H. Ebert, "Medical Education in the United States," *Daedalus* 106, no. 1 (1977): 171–184.

[114] Ibid., 172.

for reform in medical education began to mount, and slowly American universities began to increase their admission standards.[115] Henderson's published commentary on the future of medical education was therefore part of a much larger shift taking place in American universities and medical schools.

The relationship between the medical school and the College would soon change upon the inauguration of Abbott Lawrence Lowell as the twenty-second president of Harvard University. On October 6, 1909, Lowell was officially inaugurated as the new president. With his presidency came a series of reforms, many aimed at better integrating the University's faculties and resources.[116] In Lowell, Henderson found a natural ally. Henderson's 1910 marriage to Edith Lawrence Thayer, a relative of Lowell's and his former mentor T. W. Richards' sister-in-law, only served to strengthen their bond. In addition to their newfound familial tie, both men cared a great deal about improving undergraduate education and raising academic standards at the College and in the professional schools. At the time, Henderson was serving as an informal undergraduate adviser to students intending to study medicine. Shortly after the publication of Henderson's co-authored essay with Southard, Lowell asked Henderson if he would be willing to chair an ad hoc committee on points of overlap in courses at the College and the Medical School.[117]

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[115] Robert P. Hudson, "Abraham Flexner in Perspective: American Medical Education, 1865-1910," In *Sickness and Health in America: Readings in the History of Medicine and Public Health*, Judith Walter Leavitt and Ronald L. Numbers, eds. (Madison: Unirvesity of Wisconsin Press, 1978): 200-2010.

[116] In 1934, Lowell published a series of essays detailing his experience as President of Harvard University and his efforts to reform and modernize the university see, Abbott Lawrence Lowell, *At War With Academic Traditions in America*, (Cambridge, MA: Harvard University Press, 1934).

[117] Cannon, "Lawrence J. Henderson," 229.

In part due to his connection to Lowell and prominence as a scientist, Henderson's career became more firmly grounded in the Faculty of Arts and Sciences, especially after he was denied promotion within the medical school. His uncertain future at the Medical School was replaced with a newfound freedom and security at the College. In 1910 Henderson moved across the river to the College as an assistant professor in biological chemistry. His introductory course in biological chemistry—a survey course on the chemical constitution of animals and plants—was strategically designed as a liberal arts course rather than a pre-professional course.[118] Henderson continued to teach biological chemistry in the chemistry department from 1910 until 1939. From 1915 to 1920 he served as the Chairman of the Division of Medical Sciences of the Faculty of Arts and Sciences. In 1913 L.J. Henderson published *The Fitness of the Environment*—a synthetic account of the research he had conducted over the previous decade and a groundbreaking study on the significance of inorganic substances for life. *Fitness* was followed by the publication of *The Order of Nature* in 1917.

In the fall of 1919, L.J. Henderson was recruited by Johns Hopkins to serve as Chair of the Physiology Department. In an effort to keep him at Harvard, he was made an attractive counteroffer which resulted in his promotion to full professor that same year. L.J. Henderson would maintain the status of full professor until 1934, when he was appointed Abbott and James Lawrence Professor of Chemistry. The Hopkins offer, he told Raymond Pearl in a letter, "gave me conditions of work at Harvard which are entirely satisfactory."[119] Pearl expressed his disappointment, but stated that he "felt sure that Harvard would not let you leave." "You now,"

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[118] For a personal reflection on the influence of L.J. Henderson's teaching on a young chemist's career see, J.T. Edsall, "Some Personal History and Reflections from the Life of a Biochemist," *Biophysical Chemistry* 100 (2003): 11.

[119] APS, Raymond Pearl Papers Series 01 Box 12, Henderson, Lawrence J. #1 1914–1922. Letter dated December 12, 1919.

said Pearl, “have things at Harvard about the way you want them, and will have for the indefinite future.”

Pearl’s diagnosis of the situation was not entirely accurate. As part of the counteroffer Henderson had been promised the chair of the newly erected physical chemistry laboratory at Harvard Medical School. Henderson saw this as an opportunity to develop his own research program. This, however, never came to fruition. Instead, Edwin J. Cohn was chosen as the new chair of the laboratory. Cohn had previously worked with Henderson as a research collaborator from 1917–1918. Once again, the perception that Henderson was not committed enough to medicine as a science got in the way of his professional advancement at the Medical School. Henderson was perceived by his medical school colleagues as more of a true physical chemist, a scientist with only partial interest in the clinical side of things. Cohn’s work on the physical chemistry of proteins was seen as being more in line with the priorities and direction of the Medical School. This came as a major personal blow and professional disappointment to Henderson.

In 1927 Harvard University received half a million dollars from the Rockefeller Foundation to establish a laboratory to study the psycho-physiology of work in industry. The Harvard Fatigue Laboratory, which started off as a unit in the basement of the Harvard Business School, would eventually come to revolutionize physiological research in the nascent field of exercise and work physiology. In the 1930s, Henderson increasingly spent his time on campus at his office at the HFL, organizing his lectures, guiding research on human relations, and recruiting top talent to the HFL. This topic will be explored in greater detail in Chapter Four.

Experiments in Social Theory, Philosophy, and History of Science

After his appointment as chair, Henderson continued teaching at the College and at the medical school. A year prior to the opening of the Harvard Fatigue Lab, the entomologist William Morton Wheeler, urged Henderson to read *Trattato Di Sociologia Generale*, by the Italian economist and sociologist, Vilfredo Pareto. With reluctance, Henderson agreed to read Pareto's sociological treatise. His reluctance was quickly transformed into enthusiasm, and before long Henderson had mastered every detail of Pareto's dizzyingly complex *Trattato*. In the early 1930s Henderson began meeting with a small inner circle of Harvard's intellectual elite to discuss the implications and potential applications of Pareto's work. People from all corners of the university were drawn to Henderson's interpretation of Pareto's concept of the 'social system' and the development of what he called 'concrete sociology.'

Henderson's turn toward the study of social life had begun in earnest following the publication of *Blood* in 1928. In fact, his appointment as the Mills Lecturer at the University of California, Berkeley, in 1930 is evidence of his rising importance in philosophical and sociological circles. He was invited to take on this position by Berkeley professor of philosophy George P. Adams. The lectureship had for several years been filled by many of "the leading philosophers in this country and in Britain."[120] The selection committee was eager to appoint someone who could explore the "intimate relations between philosophy and science." [121] They wanted to fill the chair from time to time by "some scientist of distinction who is also interested in philosophical problems."[122] In his invitation letter, Adams remarked that the committee was

[120] HBS, LJH papers, Carton 01 Folder 1 A Misc. I – letter from George P. Adams to LJH dated January 20, 1930.

[121] Ibid.

[122] Ibid.

well aware of L.J. Henderson's "interest in and contributions to the philosophical aspects of science." Adams and other members of the philosophy department at the University of California had fond memories of Henderson's presence at the Philosophical Seminar of Professor Josiah Royce.

Henderson's engagement with issues that were not strictly of interest to scientists—such as the place of teleology in natural science—was of great interest to his philosopher colleagues. His scientist colleagues felt that his engagement of teleology was too philosophical and only served to distract from the more scientifically relevant issue of fitness of the environment. In writing his first two books, Henderson clearly asserted that there are philosophical implications to scientific findings, and that men of science "can no longer shirk the responsibility of philosophical thought."[123] The assertion that the two were inextricably related sparked great interest within the field of philosophy of science.

Eager for "a change and a rest in a pleasant climate," L. J. Henderson happily accepted the invitation. Reluctant to teach a more advanced graduate class in the philosophy of science, he settled on an undergraduate Pareto seminar. The seminar was to focus on two key texts: Pareto's *Trattato di Sociologia Generale* and Claude Bernard's *Introduction to the Study of Experimental Medicine.* One of the most interesting aspects of Pareto's book, Henderson stated in a letter, "is his discussion of scientific method, a treatment the most skeptical and the most radically empirical, so far as I am aware, that has ever been published."[124] By referring to Pareto as "radically empirical" Henderson was referring to Pareto's insistence on sticking to "the facts" and guarding against the encroachment of sentiments in scientific analysis. The evolution of the

[123] Lawrence J. Henderson, *The Order of Nature,* (Cambridge, MA: Harvard University Press, 1917): 9.

[124] HBS archives, LJH papers, Carton 01, Folder 1, A. Misc. I, letter from LJH to George P. Adams dated February 7, 1930.

Pareto Seminar and Sociology 23 will be explored in more detail in Chapter Three. Although Henderson's engagement with Pareto's social theory developed later in his career, it is clear from his correspondence with the philosopher George P. Adams that Henderson had, as early as 1913 already established himself as an individual who seriously considered the philosophical implications of his scientific work.

Henderson was interested in history as well as philosophy. Prior to his appointment as full professor, Henderson followed in the footsteps of his former mentor, T.W. Richards, and designed a course on the history of science. With President Lowell's approval, Henderson went on to teach history of science to generations of undergraduates from 1911 until 1942.[125] His lectures began with Copernicus and Galileo and ended with modern biology and medical sciences. On March 10, 1914, he told a class full of students that the "conservation of energy and the second law of thermodynamics have had more influence on pure science than the theory of evolution."[126] Evolution, he went on, "has had more of an influence on history, sociology and economics than on science pure and simple." He held up the nineteenth-century generalizations about matter as the most important step toward developing a unifying theory of nature. Still, he warned the students, "natural laws must be qualified."[127] The need to qualify does not necessarily "affect their accuracy." He gives the example of Antoine-Laurent de Lavoisier,

[125] For an account of the development of history of science as an independent academic discipline see, Arnold Thackray, "The Pre-History of an Academic Discipline: The Study of the History of Science in the United States, 1891–1941," in *Transformation and Tradition in the Sciences: Essays in Honor of I. Bernard Cohen*, ed. Everett Mendelsohn, (Cambridge: Cambridge University Press, 1984): 395–420; Joy Harvey, "History of Science, History and Science, and Natural Sciences: Undergradaute Teaching of the History of Science at Harvard, 1938—1970," 90 (1999): S270-S294.

[126] HUA, Call no. HUC8913.3.39.1 Notes on History of Science I, 1913–1914 Professor Lawrence J. Henderson, lecture dated March 19, 1914.

[127] Ibid.

whose work on the law of conservation of energy did far more than set forth "the facts"—"chemical changes were henceforth thought of as rearrangements." Henderson attempted to impart upon his pupils an appreciation for the empirical as well as the theoretical aspects of scientific inquiry.

Henderson's interest in history had left him convinced that the most important and exciting work left to do was in biology. "The Problems of Living Things," he said at the start of his lecture, "baffles and stimulates the imagination." Not shy about expressing his doubt regarding the adequacy of natural selection, as a mechanism to explain the process of evolution, Henderson went on to state that "the answer to how evolution takes place" is still unanswered. "Most men of science," he noted, "admit that there is something more besides natural selection." Acknowledging that natural selection did much to establish the theory of evolution, he pushed his students to consider that natural selection "is a factor" but perhaps not the *only* factor. Henderson's first book, *The Fitness of the Environment* (1913), was entirely devoted to articulating the very crucial role that the physical environment played in facilitating the formation and evolution of life on earth. Like neo-Lamarckians, Henderson believed that the environment played a crucial role in the evolution of life on earth. Unlike the neo-Lamarckians, however, Henderson did not believe that acquired characteristics could be inherited.

Henderson's courses were designed to raise questions about scientific content *itself*. They were also designed to present students with a formalized message about what science *is* and what it *ought* to be in the modern world. "Science," he exclaimed, "does not deal with origins."[128] In later iterations of the course, L.J. Henderson would further emphasize his view of science. A scientific theory or generalization "only needs to be useful, not true," he told his students in

[128] Ibid.

1941. “To say a thing exists or happens is only a convenient assumption; it is valuable only if it is useful.” What one needs most in science is “a conceptual scheme.”[129] Armed with a convenient conceptual scheme, scientists can then engage in experimentation: “experimentation is essential to replace accidental discovery.” Experimentation makes generalizations possible: “generalization is characteristic of science, not pre-science.” His lecture notes suggest that by 1941, L.J. Henderson’s attention had shifted from a linear progressive story of scientific development to a more theoretical, perhaps sociological, view of science as a process. He believed that description and classification were necessary precursors to scientific generalization. This, he argued, could only be accomplished by many scientists, each working with an agreed upon conceptual scheme regarding a given basic principle. The conceptual scheme served to unify their thinking in a way that extended beyond their individual research projects. “His course ended with a lecture on the place of science in civilization. “There is constant pressure,” L.J. Henderson told his students in a lecture delivered in 1941 “to adapt to a new scale of living because of the very existence of scientific improvements.”[130] Moreover, these developments have brought about the necessity for specialization, but, he warned, “the experts are a conservative force.” Despite all of these advances, however, “the laborer has not seen benefit to the extent which we would expect.” There can be no doubt, he said, “that industrial civilization is out of joint.” “No society,” he reminded his students, “is inevitable.” The point he tried to impress upon his students was that “Science is neither a moral nor an impartial force.” It is in the end, “society’s task to guide it to desirable ends.”

[129] HUA, Call number 8941.341.1.95, Box 792, 24-I-4, Class Notes for History of Science I: 1941–42.

[130] Ibid.

This proved to be his last lecture before his death nine months later in 1942.Over a decade earlier, in February 1931, just a month after having assumed his prestigious post as the Mills Lecturer, Henderson experienced a sharp pain in his lower abdomen. The pain followed by a nearly fatal gastrointestinal hemorrhage, landed Henderson in the hospital for a four-weeks stay.[131] His hemoglobin levels, his wife reported in a letter to a concerned friend, had fallen down to 32 percent. A combination of bed rest, Whipple's Liver Extract, and a diet consisting of heavy cream and eggs brought his levels back up to 85 percent in less than two months.[132] At the time his doctor concluded that his ailment, much to his wife's relief, "proved to be a duodenal ulcer."[133] Nearly a decade later, after experiencing a second attack, doctors would come to a far more devastating conclusion—cancer. L.J. Henderson's experience with being told that he had cancer would become a subject he engaged in his writings on the physician-patient relationship.

Conclusion

In the interstitial spaces of the American academy in the early half of the twentieth century, Henderson was able to move somewhat seamlessly from the physical chemistry laboratory to the classroom where he taught social theory and history of science. Some of his contemporaries were engaged in similar border crossings, but perhaps to a lesser extent. Henderson was unique in that he crossed multiple domains, yet remained firmly grounded in his identity as a physiologist. He also published on the topic of medical education, business education, and the study of society. Very few people were willing, or perhaps bold enough, to

[131] APS, Raymond Pearl, Box 12, Folder—Henderson, Edith T. 1919, 1931, letter from Edith T. Henderson to Mrs. Pearl dated April 10, 1931.

[132] Ibid.

[133] Ibid.

engage in such a vast array of intellectual enterprises. The nascent institutional structures at Harvard and other universities like it made such fluidity of movement possible in the first few decades of the twentieth century.

CHAPTER TWO

A State of Mutual Dependence: Articulating the Relationship Between Fitness and Systems

> The interdependence of the variables in a system is one of the widest inductions from experience that we possess; or we may alternatively regard it as the definition of a system. It also finds its formulation in the mathematical description of all kinds of systems.[134]

In this chapter I examine what Henderson and his contemporaries understood by "systems," in a physico-chemical sense. It outlines the basic logic of systems that Henderson used to study the relationship between environment and organisms. Henderson later transferred this same logic to his study of social interactions, a switch that will be explored in greater depth in chapters three and four.

I begin with an analysis of Henderson's articulation of the logic of systems in his first two books, *The Fitness of the Environment* (1913) and *The Order of Nature* (1917). Henderson's articulation of environmental fitness in these two books allows us to understand how Henderson defined systems and the historical significance of his contribution to a mechanistic conception of organisms and the environment. Henderson's formulation of the theory of the fitness of the environment for life inspired new research in oceanography, physiology, and geology.[135] I argue that the primacy of systems was already apparent in these two early works and that Henderson used an analysis of fitness to articulate the logic of systems more generally.

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[134] Lawrence J. Henderson, *Pareto's General Sociology: A Physiologist's Interpretation.* (Cambridge, MA: Harvard University Press, 1937), 86.

[135] Henderson's first book *The Fitness of the Environment* was reprinted seven additional times following the initial publication in 1913: 1918, 1924, 1927, 1938, 1958, 1966, and 1970. In the two latter editions from 1958 and 1970, the American Nobel Laureate, George Wald added an introduction to the text. In his introduction, Wald credits Henderson with providing the impetus for new research developments in the interdisciplinary fields of oceanography and physiology. Wald likely new Henderson, as the two men were professors at Harvard University in the 1930s. Henderson, *The Fitness of the Environment*, (New York: Macmillan, 1913).

Henderson and his contemporaries understood a "system" to be a known set of variables whose interrelations could be formally stated using symbolic logic and mathematics. They conceptualized systems as generalizable to all phenomenon involving two or more variables in a state of mutual dependence. Systems could be of a social or a physical nature (as in the case of Willard Gibbs' work on phases). This concept of system—as variables in a state of mutual dependence—marks a movement toward a more cooperative and ecological view of nature. Henderson's two books illustrate a growing emphasis in the works of biologists and physical scientists in understanding nature as cooperative, with permanence and stability in natural forms, coordination, and organization.[136]

This same trend can be seen in a growing number of publications by biologists who focused on the concept of emergent evolution, as seen, for example, in C. Lloyd Morgan's *Emergent Evolution* (1923). The concept of emergent evolution was also explored by the entomologist William Morton Wheeler in studying the formation of insect and human societies in his book *Emergent Evolution and the Development of Societies* (1928). Others, like D'Arcy Wentworth Thompson, echoed Henderson's concern that biologists had focused too narrowly on evolution—mainly the concept of survival of the fittest—to explain changes in the form and structure of living organisms. In *Growth and Form* (1917), Thompson argues that physical laws and "mechanics" ought to be considered. Henderson's work tied together these intellectual concerns and observations into a theory of cosmic and biological evolution.

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[136] D'Arcy Wentworth Thompson, *On Growth and Form*, (Cambridge: Cambridge University Press, 1917); Sir William Bragg, *Concerning the Nature of Things: Six Lectures Delivered at the Royal Institution*, (London: G. Bell and Sons, 1925); Lloyd Morgan, *Emergent Evolution: the Gifford Lectures* (London, Williams and Norgate, 1923); William Morton Wheeler, *Emergent Evolution and the Development of Societies* (New York: W. W. Norton, 1928); William Patten, *The Grand Strategy of Evolution* (Boston: R. G. Badger, 1920); Thomas Hunt Morgan, *Critique of the Theory of Evolution* (Princeton, NJ: Princeton University Press, 1916).

The chapter then examines debates regarding the role of mechanism versus vitalism in biology to provide context for understanding the impact of Henderson's first two works. Henderson believed that his conception of environmental fitness was directly relevant to the age-old debates between vitalists and mechanists. Henderson conjectured that the system, as a concept, could resolve this tension by insisting that one must take into account the specific variables and their relations as well as the *organization* of these relations. I then provide an analysis of the different intellectual communities that engaged this work and what they perceived to be the significant implications of these two books. I argue that Henderson's first two books helped build a foundation upon which systems theory could be applied to both the natural sciences and the study of human relations. This chapter shows that, for Henderson and his contemporaries, this general logic of systems provided a seamless transition among disciplinary domains.

Fitness: Organism and Environment as System

This section discusses Henderson's conception of fitness and its relationship to his articulation of the logic of systems. It specifically investigates what makes Henderson's claims about environmental fitness unique, and how those claims fit into the broader picture of early twentieth-century discussions of biological fitness and the adaptation of organisms. Henderson, it will become clear, conceived of the environment-organism relationship as constituting a system. In so doing, he articulated a logic and structure of systems and a method of analyzing problems consisting of multiple variables in a state of mutual dependence. My approach here builds upon the work of previous historians of science, including Everett Mendelsohn and Iris Fry, who have

sought to place Henderson's thinking on these topics within broader intellectual patterns in the early twentieth century.[137]

In *The Fitness of the Environment* (1913) Henderson sought a more "precise" meaning for fitness, a quantitative formulation of the fitness of the environment for life. "To what extent," he asks, "do the characteristics of matter and energy and the cosmic processes favor the existence of mechanisms which must be complex, highly regulated, and provided with suitable matter and energy as food?"[138] In other words, to what extent is the environment *fit* to support life as we know it? His answer: the unique ensemble of physical and chemical properties exhibited by carbon, hydrogen, and oxygen make earth the "fittest possible abode of life."[139] Not only was the organism fit for the environment, but the environment was perfectly fitted for life. Unlike Darwinian fitness—which is concerned primarily with the ability of an organism to survive and reproduce through the process of natural selection—Henderson was interested in fitness as a physico-chemical concept.

The Fitness of the Environment is, in a way, a collection and interpretation of examples of simple physical and chemical substances that help to illustrate the reciprocal character of Darwinian fitness. The focus was chiefly on carbon, hydrogen, oxygen, water, and carbonic acid. Henderson's interest in the topic developed from a curiosity about "the problem of neutrality or

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[137] Mendelsohn notes that Henderson's work on fitness was an extension of his studies on acid-base chemistry. See, Mendelsohn, "Locating 'Fitness' and L.J. Henderson," in *Fitness of the Cosmos for Life: Biochemistry and Fine-Tuning*, eds. John D. Darrow, Conway Morris, Stephen J. Freeland, Charles L. Harper, Jr., (Cambridge: Cambridge University Press, 2008), 3-19. See also Iris Fry, "On the Biological Significance of the Properties of Matter: L.J. Henderson's Theory of the Fitness of the Environment," *Journal of the History of Biology* 29 (1996): 155-196. In another article Fry looks at the philosophical implications of thermodynamically informed conception of evolution see, Fry, "Evolution in the Thermodynamic Perspective: A Historical and Philosophical Angle," *Zygon* 30 (1995): 227-248.

[138] Henderson, *Fitness*, 37.

[139] Ibid., v.

faint alkalinity of the organism," which then developed into the much broader question of fitness.[140] The transition in his research problem began, he states, with a "chance" reading of a paper written by the German chemist Maly in 1877 on the diffusion and dialysis of phosphates. The discovery was inexplicable to Maly in the absence of the modern theory of ionization. Henderson credited Maly's paper with inspiring a series of experiments on the study of the neutrality of the organism. It soon became clear to him that the key to understanding the "peculiar conditions" of acid-base equilibrium in blood and protoplasm is also found in the phosphate solutions that Maly had observed, as well as in solutions containing carbonic acids.

After nearly a decade of hard work on acid-base equilibrium—most importantly his development of a quantitative description of the chemical equilibrium of buffer solutions—it became clear to Henderson that phosphoric acid and carbonic acid have the "greatest power of automatic regulation of neutrality."[141] He struggled, however, to find an explanation for a fact of such far-reaching importance. Three things regarding the power of buffer solutions seemed apparent to Henderson: 1) It could not be accounted for by natural selection; 2) it could not be attributed to "mere chance"; and 3) it was not a unique or singular instance of simple substances serving a useful purpose in the process of life. "Like everyone who has received a chemical training," he states, "I was vaguely conscious of numerous other similar cases." The most obvious example of the fitness of the environment for life is that of the "remarkable thermal properties of water" which are of the upmost importance to living organisms. Prior to the publication of *Fitness* there had been almost no modern work on the role of the environment—

[140] Ibid., vi.

[141] Ibid., vi – vii.

described in physico-chemical terms—in organic evolution. Henderson had discovered biological fitness anew from the perspective of modern physical chemistry.

Henderson's insistence on the reciprocal relationship between organism and environment was not new. Indeed, Darwin had proposed this idea long before the publication of *Fitness*. Nineteenth-century natural theology attributed adaptations of organisms to the environment and the fitness of nature for the "activities of living things" to the wisdom and goodness of God.[142] For years skeptics struggled to propose a theory that could account for the apparent teleology in the adaptation of organisms to the environment without falling back on the "dogma of final causes." With the publication of Darwin's *On the Origin of Species* (1859), the hypothesis of natural selection provided skeptics with a much sought-after alternative to the concept of purpose in biology. For Darwin and his followers, the concept of fitness came out of a larger discussion of natural selection. Henderson contended that, while biologists had done much to advance the understanding of fitness in terms of adaptations of living organism to the environment, they had treated the environment, and its history, as an independent variable. Henderson instead asked: could the material universe be subjected to laws that are important in organic evolution? His inquiry into fitness therefore focused on a physico-chemical understanding of the physical environment and its ability to sustain life.

The rapid production of physical and chemical data since the middle of the nineteenth century made such a question a reasonable line of inquiry in the early twentieth century.[143] By the time Henderson published *Fitness* in 1913, physical science, he argued, had "provided the

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[142] William Whewell, *Astronomy and General Physics Considered with Reference to Natural Theology,* (London: William Pickering, 1834).

[143] Virginia M. Schelar, "Thermochemistry and the Third Law of Thermodynamics," *Chymia* 11 (1966): 99-124; Frederick D. Rossini, *Fundamental Measures and Constants for Science and Technology,* (Cleveland, OH: CRC Press, 1974).

speculative biologist with a very accurate and extensive description of the physico-chemical structure of the material universe."[144] Henderson readily acknowledged that nearly all of the facts or theories covered in *Fitness* were, by the first decade of the twentieth century, well established and well represented in encyclopedic handbooks. Henderson's unique contribution was, therefore, his interpretation of the facts as they related to the problem of biological fitness. Henderson was interested in using established facts about simple chemical substances to understand the role of the environment in shaping biological evolution.

But Henderson's goals were larger than this. Beyond biological evolution, he was interested in "cosmic evolution": the history and origins of the material universe. He argued that, "logically, in some obscure manner, cosmic and biological evolution are one."[145] In the early decades of the twentieth century, a number of scholars were aggressively attempting to answer the question of the universe's origins with scientific evidence. Replete with religious and metaphysical implications, Henderson's *Fitness* sought to move away from the religious undertones of the study of the cosmos. His goal in *Fitness*, in other words, was to establish a plausible explanation of the past and present *fitness* of the environment for life based on rigorous treatment of a half-century's worth of physical and chemical data on the behavior and properties of the most abundant chemical elements on earth. He showed how the Earth's most abundant chemicals—mainly carbon, oxygen and nitrogen—possessed the ideal properties to facilitate the evolution of life on earth. Henderson invited biologists to make use of this work in investigating the relationship between life and the environment.

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[144] Henderson, *Fitness*, 21.

[145] Ibid., 278-279.

This reciprocal relationship between the properties of matter and organic mechanisms, Henderson argued, constituted a system that could indeed be analyzed using the methods of physical chemistry.[146] This was a major move away from framing adaptation as a morphological problem. What was new about Henderson's approach was his conception of this reciprocal relationship as a system, as well as his use of evidence from physical chemistry. With life defined as a physico-chemical system, the environment became a unique ensemble of properties perfectly fitted for life on earth. The properties of the environment, he stated in the final chapter, "biologically considered, present the same fitness as the properties of life."[147]

Henderson, in other words, was writing not about a particular local environment or organism but rather about the general conditions and characteristics of the material world that constitute an environment and that environment's ability to sustain stable, diversified organisms. He used the concept of fitness to convey the "extraordinary" set of environmental conditions that are "favorable to life" in general.[148] Among these conditions he included number, variety, complexity, adaptability, availability, activity, and richness in energy of the substances involved in the metabolic process and in the chemical and physical formation of the organism.[149] Together and independently, Henderson went on, the "natural characteristics of the environment promote and favor complexity, regulation, and metabolism, the three fundamental characteristics of life."[150] Not only did Henderson claim that organism and environment constitute a system; he

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[146] Ibid., 4.

[147] Ibid., 280.

[148] For a detailed account of the meaning of fitness in Henderson's work see, Iris Fry, "On the Biological Significance," *Journal of the History of Biology* 29 (1996): 155-196.

[149] Henderson, *Fitness*, 253.

[150] Ibid., 253.

also argued that they constitute a particularly complex and self-regulating system that favors stability (in a thermodynamic sense) and diversity of life forms. After establishing the terms upon which his treatment of life and environment is based—mainly the physical and chemical perspective—he stated that living things can be simplified into "mechanisms which are complex, regulated, and provided with a metabolism."[151] Finally, he reduced the problem of life's fitness to an inquiry into the degree to which the physical and chemical characteristics of the environment—mainly water, carbon dioxide, hydrogen, oxygen, and carbon—are favorable to mechanisms which must also be physically, chemically, physiologically complex, and well regulated.[152] He concludes that the physical properties of the environment are uniquely fitted to life, life conceived as a physico-chemical system.

Defining the Physico-chemical System

Henderson's inquiry into the functions of an environment lead him to formulate his problem a different way in a short article which appeared in the journal *Science* a year after the publication of *Fitness*: "what are, speaking generally and abstractly, the relations between any material system and the rest of the world?"[153] Drawing on the thermodynamical studies of Willard Gibbs, Henderson stated that most of physical chemistry is concerned with systems, their classification, activities, and conditions of equilibrium. Henderson defined a physico-chemical system as an aggregate of matter occupying a position of space. Gibbs' phase rule, he said, made

[151] Ibid., 63.

[152] Ibid., 64.

[153] Lawrence J. Henderson, "The Functions of an Environment," *Science* 39, no. 1006 (1914): 525.

it possible to put together a complete and exhaustive classification and description of systems.[154] As such it was now possible to give a qualitative physical and chemical analysis of the fundamental characteristics of *any* system—including temperature, concentration, stability, and chemical activity.

A key characteristic of all systems, Henderson argued, is that they manifest activity. Accordingly, Henderson concluded, "mechanism has come to mean merely any active system."[155] Henderson understood "mechanism" to refer to an active system that can be described according to its fundamental physico-chemical properties—*in general*, and not to a specific mechanism. This is precisely the new definition and meaning of mechanism that Henderson employed throughout his work. For Henderson, a mechanistic explanation of a phenomenon is "its explanation as the activity of a system"; this, he explains, is "the only explanation known to physical science."[156] He went on to state that, "for the purposes of physical science no others [factors] need be, or indeed can be, introduced."[157] He was speaking directly to vitalist claims that there had to be something more than mere mechanism.

In this same 1914 article, Henderson gave a succinct definition of *the system*. Drawing once again on the work of Willard Gibbs, Henderson states that the fundamental characteristics of a system are its components, phases, concentrations, temperature and pressure.[158] Consequently, he states, fitness for *any* system involves the situation that produces the greatest

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[154] Ibid.

[155] Ibid.

[156] Ibid.

[157] Ibid.

[158] Ibid.

possible range of values for each of these fundamental characteristics of the system. As compared to other elements in the periodic table, the elements, hydrogen, oxygen, and carbon yield the highest degree of possibilities for each of these measures, therefore producing the fittest environment for life. In his second book, *The Order of Nature* (1917), Henderson followed this line of inquiry into the universality of systems a step further. Here Henderson argued that the unique ensemble of properties found in hydrogen, oxygen, and carbon show that there is a "new order"—a law-like behavior of properties—in the environment. The concept of order is, of course, closely tied to teleological conceptions of nature that had long been associated with a religious worldview. Henderson, however, saw no need for God in this interpretation of nature. Instead, he identified this order with the physical properties of the elements. In the following section I discuss how Henderson's concept of order in nature related back to his theory and logic of systems.

The Teleology of Systems

In 1916 Henderson published a brief essay titled "The Teleology of Inorganic Nature" in *The Philosophical Review*.[159] In this essay, he focused his discussion on the study of adaptation. Adaptability, like fitness, he states, "at bottom is a physical and chemical problem, uncomplicated by the riddle of life." [160] The question animating his inquiry into the teleology of inorganic nature was, "What are the physical and chemical origins of diversity among inorganic and organic things, and how shall the adaptability of matter and energy be described?"[161]

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[159] Lawrence Joseph Henderson, "The Teleology of Inorganic Nature," *The Philosophical Review* 25, no. 3 (1916): 265-281.

[160] Ibid., 265.

[161] Ibid.

Henderson approached this question primarily through the concept of system discussed above. By conceiving of the fitness of the environment for life in physico-chemical terms, Henderson was able to account for the reciprocal relationship between environment and organisms by falling back on his concept of system—a state of mutual dependence among variables.

A year later, Henderson tackled these questions in a book-length essay titled, *The Order of Nature: An Essay*.[162] In *The Order of Nature*, Henderson takes the philosophical problem of teleology head-on. "Order" here refers to the logical relationship between the properties of hydrogen, oxygen, and carbon and the characteristics of systems—a relationship that had, in Henderson's opinion, a "philosophical as well as a scientific bearing."[163] Chapters two through seven are therefore dedicated to a philosophical problem: the historical development of teleological thought.

In the *Order of Nature*, Henderson set out to produce a systematic study of the chemical origins of diversity among inorganic and organic things as well as of the adaptability of matter and energy for life. Although his previous study demonstrated the fitness of the environment for life, Henderson admitted that it "only touches the surface of the problem." The mutual relationship between organism and environment is not symmetrical; "it is something more than adaptation for it involves great adaptability."[164] In other words, in every case of adaptation, the particular characteristics of an organism fit a special environment, but its general properties—its incorporation of water and carbonic acid—fit the *general* characteristics of life. Moreover, stability, mobility, durability, complexity, and the availability of matter and energy, he pointed

[162] Lawrence Joseph Henderson, *The Order of Nature: An Essay* (Cambridge, MA: Harvard University Press, 1917).

[163] Ibid., 8.

[164] Ibid., 6.

out, are favorable to *any* mechanism, "any possible kind of life in this universe."[165] In *The Order of Nature*, Henderson attempted to demonstrate that the "primary constituents of the environment are the fittest for those general characteristics of the organism which are imposed upon the organism by the general characteristics of the world itself; by the very nature of matter and energy, space and time."[166] Life, in other words, is conditioned by the environment. Henderson saw this as proof for the existence of a "hitherto unrecognized order among the properties of matter."[167] The order to which Henderson was referring is simply the logical relation of the properties of the three elements (hydrogen, oxygen, and carbon) that are characteristic of living *systems* in general.

Henderson's conception of system is indeed teleological, but it nevertheless assumes that it is possible to study the system mechanically by considering the individual variables and their relations. He considered this order—the law-like properties observed in the material universe—to be in part responsible for the teleological appearance of nature. Henderson addressed these teleological implications directly, writing in the conclusion that it is the "principle peculiarity" of the universe—the unique ensemble of its properties, including the uneven distribution of the elements—"which makes diversity of evolution possible is original and anterior to all instances of the process which it conditions." [168] This order is original to the very structure of the universe

[165] Ibid.

[166] Ibid., 7.

[167] Ibid.

[168] Ibid., 199.

and ensures evolutionary developments. In other words, neither fitness nor evolution—of life or the physical world—can be "regarded as merely contingent."[169]

In his final chapter on "The Teleological Order," Henderson revisited Aristotle's framing of the teleological problem: "the character of the material nature whose necessary results have been made available by rational nature for a final cause."[170] Henderson translated "rational nature," nature conceived by human reason, into the modern term "*laws of nature*."[171] These laws are rational in that they are the product of human reason and do not have an objective existence. This, he said, "is clearly true of the *relation* between the properties of the elements and the characteristics of systems." In other words, the teleological order observed in nature is essentially natural law. He continued, "all phenomena are phenomena of systems." Consequently, final causes can only operate through the evolution of systems. As such, greater freedom for the evolution of systems "involves the greatest possible freedom for the operation of a final cause."[172]

At last Henderson arrived, full-circle, at a simplified version of the teleological implications of his investigation: How do we account for the characteristics of material nature whose necessary results have been made available by the laws of nature for any hypothetical final cause?[173] Again, Henderson asserted that the uniformity of the characteristics of material nature throughout space means that there cannot have been "any contingency about the operation

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[169] Ibid.

[170] Ibid., 200.

[171] Ibid. (emphasis in original).

[172] Ibid.

[173] Ibid., 201.

of this cause."[174] Consequently, the properties of these elements "are to be regarded as fully determined from the earliest conceivable epoch and perfectly changeless in time."[175] He based this conclusion upon experimental evidence, namely astronomical spectral analysis that had been made available in the late nineteenth century.[176] He concluded that the "abstract characteristics" of systems must also be regarded as fully determined and changeless in time. Based on this line of reasoning and evidence, Henderson argued that the connection between the properties of the three elements—carbon, hydrogen, and oxygen—and the evolutionary process is teleological and non-mechanical.[177]

To summarize his argument, Henderson recapitulated the conclusion upon which his analysis rested: 1) All phenomena are phenomena of systems and therefore the characteristics of systems (phases, components, activities, etc.) are the universal conditions of all phenomena. In other words, the characteristics of systems do not depend on the peculiarities of matter, and they are changeless; and 2) the three elements—carbon, hydrogen, and oxygen—possess an ensemble of unique characteristics that should be considered fundamental properties of life.[178] This pattern produced by the combination of these three elements is a universal condition of organic phenomena and therefore systems. The relationship between these two abstract qualities of the universe cannot, he argued, be conceived as dependent. Unlike mechanically conditioned

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[174] Ibid.

[175] Ibid.

[176] For an historical overview of the role of spectral analysis in the field of astrobiology and theories of extraterrestrial life see Stephen J. Dick, *Life on Other Worlds* (Cambridge: Cambridge University Press, 1998).

[177] Henderson, *The Order*, 204.

[178] Ibid., 209.

relationships where there is an opportunity for modification through interaction, as is the case in organic adaptations, the absolute properties of the universe are supposed to be changeless in time. Unable to give a mechanistic account of the relationship between universal systems and the fundamental properties of matter, Henderson concluded that the two must have a "functional relationship that can only be described as teleological."[179]

Reception

Henderson's first two books were received with great interest, if not always positively. The public response to them gives some indication of their significance and timeliness. The books raised anew age-old debates about mechanism versus vitalism, the place of teleology in science, and the underlying nature of the evolutionary process. Among the various reviewers, we find commentary from scientists, philosophers, journalists, and religious scholars. It was treated by philosophers with great skepticism and at times outright animosity. Scientists saw it as a step forward, but felt that Henderson's engagement of the philosophical implications of his scientific findings only served to confuse the more important issue of the role of the environment in the process of organic and cosmic evolution. To many of Henderson's readers the two books were seen as either a restatement of the obvious or "a curiously tangled mixture of idealism and scholastic realism."[180] Most of these reviews leave the concept of systems largely untouched; instead, what resonated most with audiences was Henderson's claim that the existing environment was the fittest possible abode for life.

[179] Ibid., 211.

[180] Harold Chapman Brown, "The Order of Nature by Lawrence J. Henderson," *The Journal of Philosophy, Psychology, and Scientific Methods* 14, no. 20 (1917): 558.

In a short, but largely positive review, the biologist Raymond Pearl applauded *The Fitness of the Environment* as the "logical sequel" of Darwin's *The Origin of Species*.[181] He considered the book an intellectual achievement that "invites and creditably sustains comparison with that milestone marking the progress of human knowledge."[182] He noted that since the publication of William Whewell's *Bridgewater Treatises*, there had been no systematic effort to examine the "specific fitness of the basic elements of the environment for the requirements of organic life."[183] In addition, he pointed out, the principle of natural selection or any other mechanistic explanation "utterly fails" to explain the fitness of the environment for life. Henderson's most important achievement, in Pearl's assessment, was his ability to show, conclusively, "that for living things constituted as are the only living things we know about, it would be impossible, with the physical agencies and chemical compounds now known, to construct an environment in fundamental respects better adapted to the needs of organisms than is the environment which exists in this earth."[184] It was the interpretation and implications stemming from these findings, not the findings themselves that inspired subsequent debate.

Henderson's claim that the earth was indeed the *fittest* possible abode for life turned out to be one of the most controversial arguments presented in *Fitness*. Interestingly, a scholar of religion, G.B. Foster, publishing in *The American Journal of Theology*, considered this to be one of the most intriguing insights of Henderson's *Fitness*.[185] Like Pearl, Foster pointed out that,

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[181] Raymond Pearl, "Natural Theology without Theistic Implications," *The Dial* 55, no. 652 (1913): 111.

[182] Ibid.

[183] Ibid.

[184] Ibid.

[185] G. B. Foster, "The Influence of Environment," *The American Journal of Theology* 17, no. 3 (1913): 457.

although we have known about the fitness of the organism for its environment since Darwin's day, the fitness of the environment *for the organism* is indeed a rather novel finding. For Foster, this insight "stimulates reflections of both a philosophic and religious character."[186] An anonymous writer for *The Biblical World* was similarly interested in the theological implications of Henderson's writings. Henderson, he wrote, allows for the possibility of the operation of a teleological tendency at the very beginning of the process of cosmic evolution. Noting that this was nothing more than the doctrine of "first cause," the writer felt that Henderson left the vital question unanswered: Can philosophy and theology live in a mechanistic world?[187] Ironically, this was precisely the question that Henderson hoped to avoid by being agnostic as to the question of the origin of this newfound fitness. Foster, in contrast, was especially taken by the potential theological implications of Henderson's views. In concluding his assessment, Foster noted that if Henderson's argument was not quite enough for the "entire religious need, it is quite too much for irreligion." On this point, Pearl and Foster parted ways. Pearl regarded Henderson's engagement of the philosophical implications of the fitness of the environment as falling short "in compelling logical force, of the purely scientific part of the work."[188]

Taking a strong stance against Henderson's claim that the earth is the fittest possible environment, psychologist Howard C. Warren argued that acknowledging that the environment is well fitted for life as we know it does not imply that there could not be a different set of inorganic conditions in which a "different type of organism might have arisen."[189] In Warren's

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[186] Ibid.

[187] "The Fitness of the Environment," *The Biblical World* 41, no. 4 (1913): 285.

[188] Pearl, "Natural Theology," 111.

[189] Howard C Warren, "The Study of Purpose. III: The Role of Purpose in Nature," *Journal of Philosophy, Psychology, and Scientific Methods* 13, no. 3 (1916): 65.

view, inorganic teleology is founded on particular facts, not the unchanging general facts that Henderson identified as "the new order" among the elements. As such, Warren criticized Henderson for not accounting for what he refers to as "unfitness."[190] In another review, Ralph Lillie pointed out that Henderson's *Fitness* is in part an attempt to rehabilitate the natural theology of Paley "with an appeal to the results of modern physical science."[191] Lillie opined that most biologists would likely consider Henderson's central thesis as "either self-evident or inherently unprovable" and would instead prefer to regard the book as a "scientific essay on the biological importance of the more general and elementary properties of the elements and compounds entering into the formation of protoplasm."[192] Much like Warren, Lillie maintained that, although the existing environment may be the best for organisms as they have come to exist, it might not be the best for the living beings of another "quite different cosmos."[193] Lillie did credit Henderson with showing that the ultimate constitution of the environment possesses characteristics that correspond with the living organism. The discovery of this truth, he stated, "will no doubt surprise many others, just as it surprised him [Henderson]."[194] In Lillie's opinion, this was Henderson's most important contribution to biology. In Lillie's view, the chief aim of biology "is to show how the characteristics of the organism are related, and ultimately proceed from those of the environment."[195]

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[190] Ibid.

[191] Ralph S. Lillie, Review of *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter*, by Lawrence J. Henderson, *Science* 38, no. 975 (1913): 337.

[192] Ibid., 339-340.

[193] Ibid., 339.

[194] Ibid., 340.

[195] Ibid., 341.

Other reviewers took the teleological argument in a different direction. The philosopher Arthur Mitchell noted that Henderson's argument implies "not only that one may learn the true nature of the universe from the biological point of view, as the environment fit for life, as well as learn the true nature of the organism from the evolutionary point of view as the agent fitted to exploit its environment."[196] Still, Mitchell felt that Henderson had not gone far enough in investigating the philosophical implications of his own insights. Mitchell believed that there was yet a "profounder idea" implied in Henderson's argument. He claimed that the biocentric universe revealed that there was indeed a teleological tendency working steadily through the whole process of evolution. This tendency is at the very origin of things and is a necessary associate of mechanism.[197]

Still others were far less enthusiastic about Henderson's treatment of the teleology problem. Another philosopher and former student of William James, Harold Chapman Brown, wrote that Henderson's effort to "give teleology a deeper and more acceptable interpretation" had not been "wholly successful."[198] Henderson's failure to grasp the teleology problem, he went on, arises from his "theory of knowledge rather than from the facts."[199] In an effort to trivialize Henderson's work, Brown stated that the universe is indeed rich in sources of wonder and that "science can do little to dispel them."[200] He agreed with Henderson in his claim that, if it were

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[196] Arthur Mitchell, Review of *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter*, by Lawrence J. Henderson, *The Journal of Philosophy, Psychology and Scientific Methods* 10 (1913): 693.

[197] Ibid.

[198] Harold C. Brown, "The Order of Nature," 557.

[199] Ibid., 558.

[200] Ibid., 559.

not for the unique properties of carbon, hydrogen, and oxygen, life would be a very "different sort of living organism," but why, he asks, "is this teleology?" In other words, for Brown, this was not a dispute of facts but one of epistemology. The two men utilized a different conception of teleology and its implications for a philosophy of life.

Interestingly, another former student of William James, Edwin B. Holt, also wrote a response to Henderson's *Fitness*.[201] Like Pearl, Holt argued that Henderson had indeed overstepped the boundaries of natural science and ventured too far into the field of metaphysics. Like Brown, Holt felt that in introducing a teleology that "lay not in his empirical data but was insidiously contained in his procedure and his instrument of thought," Henderson had simply succeeded in illustrating "human frailty."[202] This "infirmity," he continued, could be described as the "misapplication of concepts." Holt criticized Henderson for reaching too far with his application of the concept of teleology to describe the fitness between environment and living systems. For this reviewer, Henderson's use of teleology was mere "factitious enhancement," an unnecessary strategy for making sense of patterns that exist in nature.[203] Holt's efforts were motivated by the goal of vindicating the "cause of unqualified mechanism" and "illustrat[ing]…the locus of concepts." By this he meant the proper application of philosophical concepts.

Forging a similar critique, but attacking a different concept, the philosopher Ralph Barton Perry focused on Henderson's use of the term probability.[204] Perry argued that Henderson's

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[201] Edwin B. Holt, "Professor Henderson's "Fitness" and the Locus of Concepts," *The Journal of Philosophy, Psychology and Scientific Methods* 17, no. 14, (1920): 365-381.

[202] Ibid., 366.

[203] Ibid., 367.

[204] Ralph Barton Perry, "Purpose and Systematic Unity," *The Monist* 27, no. 3 (1917): 371.

misunderstanding of probability had led him to erroneously conclude that the fitness of the environment for life, remarkable as it may be, must have been from design. "It is not proper to infer," Perry stated, "a law from a single simultaneity, but only from a succession of simultaneities." Perry wrote his "dissent" from "the view that purpose is exhibited in all cases of system and unity," including the phenomena of life.[205] Purpose, he argued, is to be unmistakably found in the "behavior of man," in particular cases of action. In Perry's assessment, Henderson's error was in applying the concept of purpose to describe the inorganic world. This, he argued, was a "doubtful extension of a conception derived from the datum of life."[206] In the three reviews by philosophers discussed so far, then, the concern was primarily with Henderson's "boundary crossing" into the realm of philosophy. The philosophers who did review his work felt that Henderson had failed in his deployment of philosophical concepts. They left the empirical evidence unchecked.

A fourth philosopher, however, J.E. Creighton, had an overall positive assessment of Henderson's *Order*. Creighton felt that Henderson had done a good job of calling attention to the fact that both the biological and the physical sciences must now recognize the existence of an order that is not merely mechanical. This order forms "the 'organization' or 'system' or 'pattern' within which mechanical causes have meaning or relevancy."[207] Creighton pointed out that this view was fundamentally teleological, not only in the sense that it posits a complementary relationship between the different elements of the 'system,' but also in the sense that earlier

[205] Ibid., 375.

[206] Ibid.

[207] James E. Creighton, "The Order of Nature: An Essay by Lawrence J. Henderson," *The Philosophical Review* 27, no. 6 (1918): 659.

stages of the evolutionary process must be regarded as a "preparation" for the next stage.[208] Although biologists would readily admit to the importance of organization, he noted, the idea that the physical sciences must also assume there to be order in systems of phenomena is not readily apparent. This was, in Creighton's opinion, one Henderson's most important contributions. In order to successfully make this claim, Henderson had to show that the "problem of teleological form and behavior of the organism merges in the larger question of the order of nature." He rightly pointed out that Henderson did not confine himself to calling attention to the teleological appearance of the world as a whole. This, he said, is a fact that is no longer possible to doubt. Instead, the bigger question in the *Order of Nature* is how the production of order is to be scientifically explained.

Creighton's review additionally suggested a growing acknowledgement among scientists and philosophers of science for each other's work. "One cannot read *The Order of Nature*," he wrote, "without realizing that philosophy and science are not opposed, or even separable methods of inquiry, and that the distinction between them is in the end provisional." Noting that Henderson would likely disagree with this statement, Creighton went on to state that throughout the book one finds "cropping up here and there in the pages a strange hesitation in regard to philosophical results, and also the old assumption that mechanism affords a kind of intelligibility."[209] In Creighton's opinion, Henderson's argument used mechanism as an instrument that contributed to the intelligibility of reality in terms of individual, interacting, systems. This suggested that scientists might be becoming more open to philosophical reflection in an effort to make sense of "concrete categories which are demanded by the actual facts of

[208] Ibid.

[209] Ibid., 663.

experience."[210] Nevertheless, in Creighton's opinion, Henderson had failed to realize the potentially transforming effect of the concepts he had helped to establish for natural science. Like Mitchell, Creighton critiqued Henderson for not going far enough. Creighton was quick to contrast Henderson's commitment to mechanistic explanations with those of Haldane, whose "primary point of departure," in Creighton's opinion, "is furnished by the facts of the organic world."[211] Like Haldane, Creighton believed that strict adherence to mechanical dogma had only hindered people from dealing with "the facts of biology."[212] Like others of his day, Creighton was of the belief that mechanism could no longer be regarded as a complete and final answer to the problems raised by the physical sciences.[213]

The popular press also took note of Henderson's first two books. The *New York Times* ran a brief review of *Fitness* shortly after its publication.[214] "For all who have felt that the origin of life in the world….needed further explanation than that given by theology in…its naïve forms," the author wrote, "there is much of interest in professor Henderson's inquiry…"[215] The reviewer went on to state that Henderson's inquiry into the properties of matter and their correlative fitness for life on earth had lead Henderson to assume that life is "no more mysterious, no more in need of teleological explanation, than matter."[216] Like other reviews

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[210] Ibid., 664.

[211] Ibid., 665.

[212] Ibid.

[213] Ibid., 663.

[214] "Origin of Life: Prof. Henderson, Dualist, Combats Various Theories," *New York Times* (1913): BR155.

[215] Ibid.

[216] Ibid.

appearing in academic journals, the *Times* reviewer honed in on Henderson's claim that matter shows as much fitness to life as life does to matter—the reciprocal nature of fitness. This, as noted above, was a main point of contention for Henderson's scientific colleagues (with the exception of Raymond Pearl). The reviewer saw in Henderson's argument a hidden dualism. Henderson, he argued, "sees in life a something more—a something unique, scientifically inimitable and inexplicable." This "inexplicable" part of this was Henderson's admission that although fitness is a *fact* it cannot be mechanistically explained. The reviewer placed Henderson's book within the context of ongoing debates about the place of teleology in science. The old version of teleology, "argument from design," was finally in ruin and admitted to be so, "even by dualists, or at least by all of them who have given any attention to scientific investigation."[217]

That same year, *The Independent* ran a short essay on "Fitness and Purpose."[218] Like Creighton, the author opined that philosophy "cannot make its account without science."[219] He considered Henderson's claim that teleology is a necessary associate of mechanism as one of the most important insights to have emerged from the publication of *Fitness.* He noted that many studies had taken for granted that the physical environment is something ultimate. Those studies had treated the evolution of the organism as a process of adjustment to this environment. Henderson, in contrast, asked if fitness is accidental or if it were instead possible to find a "law" that could account for the remarkable fitness of the environment for life. The reviewer's assessment was that Henderson's view was an "impressive" and "startling, exposition of the unity of our world."

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[217] Ibid.

[218] "Fitness and Purpose," *The Independent* 75, no. 3379 (1913): 570.

[219] Ibid.

A third review appeared in the *New York Times* in 1925 under the title "Man Lives in a World Made to Order."[220] Like the previous reviews, this author was struck by Henderson's assessment of the reciprocal relationship between fitness of the environment for life. This review was published following the reprinting of *Fitness* in 1924, which triggered a resurgence of popular interest in Henderson's argument for the fitness of the environment and its implications.[221] These three reviews, which appeared in prominent and widely circulated papers, suggest a broad interest and readership. For a certain segment of the reading public, the most intriguing issue was Henderson's argument about the suitability of the environment for life.

In response to the objections aired in the scholarly reviews, Henderson published a brief essay in *The Journal of Philosophy, Psychology and Scientific Methods* in 1916. "I can not help thinking," he retorts, "that my critic [Warren] has been hasty in supposing that any man of science, approaching this subject from the frontiers of physics and chemistry, could to-day hold such silly views."[222] Henderson was "anxious to point out the facts which" he believed Warren had overlooked and to make the case for inorganic teleology.[223] Reiterating his main argument, and, as he put it, "putting aside all vain speculations about other possible worlds in which matter may have different properties and energy different forms," Henderson attempted to clarify his point once again.[224] The first fact, he noted, is that the physical and chemical properties that

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[220] Benjamin Harrow, "Man Lives in a World Made to Order: A Physical Chemist Analyzes Our Friendly Environment," *New York Times* (1925): BR16.

[221] Henderson, *The Fitness*.

[222] Lawrence J. Henderson, "Teleology in Cosmic Evolution: A Reply to Professor Warren," *The Journal of Philosophy, Psychology and Scientific Methods* 13, no. 12 (1916): 326.

[223] Ibid.

[224] Ibid.

constitute the earth "make up a unique ensemble of singular physical and chemical characteristics."[225] "Secondly," he continued, "the world of physics and chemistry consists exclusively of systems."[226] Appealing to the authority of Willard Gibbs, Henderson reiterated that this is a recognized postulate of science. Systems, he continued, consist of phases, components and are characterized by concentrations and different forms of activity (such as pressure and heat).[227]

Henderson also tried, in this response, to clarify his thinking on the teleological conclusion of *The Order*. For Henderson, this was nothing more than the acknowledgement that the environment is made up of a unique ensemble of properties. These properties are uniquely favorable to the existence of systems, as defined by Gibbs. These systems favor number, diversity, and durability. No other known elements or substances even come close to approaching the kind of fitness for the proliferation of systems than hydrogen, carbon, and oxygen. Most importantly, for Henderson, this conclusion did not rest on a single observation. Instead, it was based on evidence from a variety of geophysical phenomena, including the meteorological cycle, the variety of dissolved material in the ocean, the temperature of the earth, and the penetration of water into soil.[228] Speaking directly to Warren's critique regarding the search for evidence of "unfitness," Henderson stated that in all of his investigations he had yet to find a single instance of unfitness of the environment for "systems in general."

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[225] Ibid.

[226] Ibid., 327.

[227] Ibid.

[228] Ibid.

Here again, then, Henderson was stressing that his main argument in *Fitness* concerned systems—defined generally as physico-chemical systems—and their general fitness for the production of diverse life forms on earth and the course of cosmic and terrestrial evolution. He added one opinion: "the relationship between the properties of the three elements and the general characteristics of systems appear to be exclusively teleological."[229] This opinion was an induction from logic, he pointed out, as neither of the terms of the relationship is liable to modification over time. In other words, the elements as they appear to us today have been unmodified and "systems will be systems as long as mass is mass."[230]

Speaking directly to the question of whether or not life would be different in other places, Henderson stated that he had no doubt that Professor Warren is right in asserting that life would be different if it were silicon-based, rather than carbon-based. However, if life were in fact possible under such conditions, it "would be restricted by any chance that excluded water or carbonic acid from the environment." In the correspondence between Henderson and his critics, particularly in this initial response to Warren, one sees a gap between Henderson's description of life as physico-chemical system and a more biological understanding of life in a specific environment. Henderson had, in *Fitness* and *Order*, simplified life and environment to terms that were legible to the average chemist of his day. This mode of conceptualizing living things, however, had not yet taken hold among most biologists.

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[229] Ibid.

[230] Ibid.

There was yet a third community of readers who engaged Henderson's work. This was, of course, social scientists and such figures engaged in reengineering the industrial workplace as Chester Barnard and Elton Mayo. This community found much inspiration in Henderson's writings on fitness, adaptation, and order. They found in Henderson's writings justification for a new approach to the management and organization of the modern workplace. What were, they asked, the properties that determined the smooth functioning of the industrial workplace? How do we determine whether or not someone is a good fit? In what kind of environment does creativity and stability thrive? To answer these questions, they looked to Henderson's conception of fitness and order. Henderson himself also went on to apply his concept of system to study the interactions that took place between doctors and patients. The movement of Henderson's concept of system from a study of the physical environment to social interactions will be discussed in depth in the following chapters. In each, Henderson and his acolytes used the same approach and understanding of systems to study social phenomenon.

CHAPTER THREE

Constituting a Social System: The Case of the Physician Patient Relationship

This chapter examines Henderson's conception of a social system through the case of medicine. Henderson saw the doctor patient-relationship as a paradigmatic example of the social system. He used the relationship between the physician and the patient to define this system, demonstrating how the parts of the system related to one another and how the method could be used to explore interactions between persons. The main goal of this chapter, then, is to provide a robust overview of what Henderson's concept of system meant in the context of social interactions and for the scientific study of social life.

For Henderson, conceptualizing the doctor-patient relationship as a social system provided a way to critique the lack of attention to the importance of social relationships in medical practice. At a moment when new diagnostic technologies and treatments were universalizing conceptions of disease, Henderson and some of his contemporaries—such as G. Canby Robinson, Richard C. Cabot, and Henry Sigerist—in social medicine insisted on the importance of context for the proper diagnosis and treatment of the sick. Henderson saw medicine as the ideal profession in that it required its practitioners to straddle the fence between the practical—directly dealing with patients—and the theoretical—biomedicine—at all times. The movement from an abstract concept of disease to the application in the clinic demanded, in Henderson's opinion, keen attention to social interactions. As Henderson saw it, doctors could not avoid the task of having to move between two worlds—the abstract world of science and the practical world of the clinic, between knowing the body as an organism and knowing the patient

as an individual. It was in understanding this tension that Henderson's efforts to elaborate a theory of social system offered promise to both social science practitioners and clinicians alike.

What did it mean for a physical scientist to insist that he could legitimately read a set of social interactions as a kind of scientific system that followed the same rules as, say, the biochemistry of blood? It was indeed somewhat paradoxical that Henderson, a man who had never actually practiced medicine would write somewhat pompously about the doctor patient relationship and medical practice. The middle decades of the twentieth century were an important time for contacts between medical science, social science, and social theory. I argue that Henderson's construction of the doctor-patient relationship as a social system should be thought of as an important conceptual bridge between the laboratory and social life. To do so, I examine not only Henderson's writings on medicine as a social system, but also how he developed those ideas in the context of the classroom.

Medicine as Social System

In 1967, twenty-five years after Henderson's death, Dr. John H. Talbott, Henderson's friend and colleague, described Henderson as "endowed with remarkable perception and profound wisdom," an individual who "displayed an amazing understanding of bedside medicine." [231] This statement was all the more remarkable given that Henderson never actually practiced medicine. He saw himself as completely "incompetent in the clinical aspect" of medicine and "in dealing with the actual living organism even in a physiologist's way."[232] In addition, not one of his scientific, medical, or popular works published between 1907–1932

[231]John H. Talbott, "At the Bedside," *New England Journal of Medicine* 277, no. 3 (1967): 113-114.

[232] HBS Archives, Lawrence J. Henderson Papers, Carton 1, Folder 29, letter to W.B. Cannon, October 03, 1917.

makes any reference to patient care or medical practice. It wasn't until 1934 that Henderson began to apply, at least publically, his sociological insights to the practice of medicine.

Henderson turned his attention toward medical practice in the later part of his career. He made this move after becoming more familiar with the work of the Italian economist and sociologist, Vilfredo Pareto, in late 1927. Henderson was introduced to Pareto's work by his colleague, the Harvard entomologist William Morton Wheeler. Though skeptical at first, Henderson soon became engrossed in reading Pareto's *Trattato Di Sociologia Generale* in French translation. In this work Henderson found what he believed to be the most promising writing on a scientific approach to the study of society. "The central feature of Pareto's General Sociology," Henderson wrote in 1937, "is the construction of a similar conceptual scheme: the social system."[233] He found Pareto's social system to be logically analogous to Willard Gibbs' physico-chemical systems, which held that systems are composed of individual components (individual people) that exist in separate heterogeneous phases (social roles: families, trades, and professions); together, they form a system.[234] Just like in the physico-chemical system, the "parts and forces" of Pareto's social system "are conceived as in a state of mutual dependence."[235] The "forces" in Pareto's social system are the sentiments—non-logical verbal elaborations expressing an individual's beliefs and values—"residues"—core values maintained by individuals which are made visible to the sociologist—and "derivations"—verbal rationalizations. Henderson and his contemporaries believed that Pareto's work could be applied to "all instances of interactions between persons," including sociology, law, history, religion, business, education, and

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[233] Lawrence J. Henderson, *Pareto's General Sociology: A Physiologist's Interpretation* (Cambridge, MA: Harvard University Press, 1937): 16.

[234]Ibid., 10-15.

[235]Ibid., 17.

medicine.[236] Interactions thus become a way of generalizing about relationships. Henderson believed that Pareto's insights could be applied to all areas of study involving interactions between people, with the ultimate goal of developing a science of human relations.[237] Over the next decade, Henderson would work through the possibilities of a Pareto-based science of human relations in a seminar that came to be known as the Pareto Circle, more about which will be said below. For now, suffice it to say that Henderson understood medical practice, and the relationship between doctor and patient, as just one more example of an area that might profitably be understood as a social system.

Henderson began speaking about what he referred to as the sociological aspects of medical practice to medical audiences, including first-year medical students, graduating medical students, practicing physicians, and medical faculties, in the early 1930s. His first publication on this theme was published in the *New England Journal of Medicine* in 1935 and was titled, "The Physician and Patient as a Social System." This paper was based on an address Henderson had delivered at the Harvard Medical School colloquium in December 1934 and again at a medical staff meeting at Massachusetts General Hospital in the winter of 1935; he delivered a later version at the spring 1935 meeting of the Association of American Physicians. It was, in other words, his first attempt to share his thoughts on medicine as a social system with those who actually participated in the practice of medicine.

In "The Physician and Patient as a Social System" Henderson offered both a critique and a potential solution to, what he perceived to be a growing tendency to disregard the "personal relations between the physician and the patient" in modern medical practice. His critique

[236]Ibid., 18.

[237]HBS Archives, Lawrence J. Henderson Papers, Carton 3, Folder 3-5, Sorokin, P.A., letter dated December 29, 1933.

focused chiefly on medicine's failure to develop a scientific and systematic understanding of the personal relations between physician and patient. Medicine, he argued, had failed to recognize the central role of social relations in the everyday practice of medicine. "A multitude of important new facts and theories, of new methods and routines, so far absorb the physician's attention" that personal relations "seem to have become less important."[238] When the personal relations of the physician with his patients are understood at all, they are understood "at the empirical level, as they were in the days of Hippocrates." After years of practice wise and skillful physicians might have an intuitive understanding of the role of personal relations in medicine, but "their skill dies with them except when their apprentices have learned in some measure to imitate them." Henderson believed that a firm understanding of the personal relations between physician and patient was not only important, but absolutely necessary for the effective and responsible practice of medicine. Yet despite numerous scientific advances in medicine, the personal relations in medicine remained immune to scientific formulation. Henderson's radical suggestion was to approach personal relations in much the same way as other natural phenomenon. What was needed was "some kind of theory, working hypothesis, or conceptual scheme" for the doctor-patient relationship. Henderson theorized, "A physician and a patient make up a social system."

Throughout the lecture, Henderson described the moral responsibilities of the physician to his patient, as well as the attitude a physician should take toward his patient. And yet, he was not arguing for a return to the past, or for limiting the use of technology or science in medicine. Instead, he pointed to the gap between medical science and social sciences. Although physicians now applied the study of different aspects of disease and the body (down to the cellular level) to

[238] Lawrence Joseph Henderson, "Physician and Patient as a Social System," *New England Journal of Medicine* 212, no. 18 (1935): 819.

their medical practice, the social relations that constituted a large part of medical practice had not been treated scientifically.[239] Henderson was, in a way, saying that physicians needed to be more scientific, not less. And, in fact, what he offered in this paper was something that could be thought of as a social technology, a way of seeing and observing, recording, and interpreting social behavior.

What Henderson was after was the formulation of an effective means of transmitting acquired clinical knowledge. "Scientific formulation," he argued, was a "necessary condition" for achieving this end.[240] For the purpose of scientific formulation, "some kind of theory, working hypothesis, or conceptual scheme is necessary."[241] This was no mere economy of thought; Henderson claimed that an effective conceptual scheme provided a means of remembering the "successful and economical thought of the past."[242] A truly "well learned theory" is not learned by rote memorization, it is "remembered in the right place at the right time, and this is a necessary condition for its use." [243] In order to be able to apply a theory at the right place and at the right time, Henderson argued, one needs a conceptual scheme.

Henderson's faith in the importance of conceptual schemes to improve the practice of medicine perhaps explains why each of his two published articles on this topic attempt to illustrate, first, how one develops a conceptual scheme based on observation and experimentation, and second, how one might use a conceptual scheme to guide the use of

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[239] Ibid.

[240] Ibid.

[241] Ibid.

[242] Ibid.

[243] Ibid.

generalizations gained through observation. Fully developed, the conceptual scheme to which Henderson refers is the social system. In "The Physician and Patient as a Social System," Henderson begins this effort by stating that his "first subject is the theory of the relation between physician and patient." [244] In building up this idea of the conceptual scheme—in going back and forth between defining and illustrating the development of the conceptual scheme and also its use—Henderson draws on examples from a broad range of sources, including a discussion of Machiavelli's science of statecraft, Willard Gibbs' generalized physical chemical system, Lord Chesterfield's letter to his son describing his efforts to convince the House of Lords to adopt the Gregorian calendar, and a discussion about the responsibilities of a physician to his patient.

In suggesting that medicine apply the terms and methods of social science, Henderson was not simply suggesting a particular kind of scientific method. The key to understanding this approach as scientific is Henderson's emphasis on the ability to transmit and preserve acquired knowledge. The ability to transmit and preserve acquired knowledge differentiates science from a purely empirical enterprise. If medicine were to be fully scientific, it would have to find a way to effectively transmit acquired knowledge from one doctor to another about the personal relations that constitute a large portion of everyday medical practice as part of social formation.

Henderson was fond of saying that professional psychologist and sociologists possessed almost no scientific knowledge about personal relations.[245] By scientific knowledge he was referring to knowledge gained by systematic observation using a standardized methodology. He claimed that the social sciences lacked a standard methodology by which to acquire systematized knowledge about human interaction. This was of course an exaggeration. Efforts to establish a

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[244] Ibid.

[245] Lawrence J. Henderson, "The Study of Man," *Science* 94, no. 2427 (1941): 1-10.

science of human relations flourished in the mid-1930s. The Rockefeller Foundation's Spellman Memorial Fund dedicated large sums of money to establish the Yale Institute of Human Relations in 1929, the social sciences at the University of Chicago, and human relations at Harvard. For Henderson, this lag was particularly galling in medicine, a field in which the understanding of disease had improved, but understandings of social relationships were at best empirical. Physicians' understanding of personal relations in medicine had advanced little since "the days of Hippocrates." There was, in Henderson's view, no systematic way of thinking about the sociological aspects of medical practice.

Sociology as the Science of Interactions

Henderson's understanding of the sociological aspects of medical practice make more sense when placed in the context of the definition of "sociology" and "sociological problems" common at Harvard at the time. Fortunately from the historian's perspective, we have ready access to Henderson's thoughts on this topic in the form of lecture notes for Sociology 23: Concrete Sociology, a course that Henderson first taught at Harvard College in 1933 (he would teach a slightly revised version of the course at Harvard Medical School five years later).[246]

The course developed out of an informal gathering that has been memorialized as the Pareto Circle and at the time was referred to as the Pareto seminar. Henderson organized the Pareto seminar in the early 1930 to bring together an elite group of Harvard intellectuals from across the university—including Talcott Parsons, Joseph Schumpeter, Pitrim Sorokin, Fritz Roethlisberger, Hans Zinsser, Clyde Kluckhohn, W. Lloyd Warner, Elton Mayo, Crane Brinton, Bernard DeVoto, Henry Murray, A. Lawrence Lowell and Chester Barnard—to explore how Pareto's insights might be applied to their respective areas of practice. A number of graduate

[246] Lawrence J. Henderson, "Sociology 23: Introductory Lectures" (1938).

students—such as Robert K. Merton, Kingsley Davis, William Foote Whyte, and George C. Homans—who would go on to become major figures of mid-twentieth century social science also participated in the seminar. Henderson saw this gathering of minds as an opportunity to "weaken the constraints that are imposed by our department organization and exclusive professional point of view."[247] Reading Pareto's *Trattato*, he explained to the sociologist, Pitrim Sorokin, affords a useful opportunity to bring together people who are separated by the relatively rigid organization and professionalist traditions of the university."[248] As discussed in chapters one and two, Henderson's interest in the nature of scientific reasoning and organization grew out of his participation in the Royce seminar and his work on fitness early in his career. The Pareto seminar was a way for him to promote his views on scientific methodology, epistemology, and the relevance of systems thinking for the study of social life. Although most literature on the Pareto Circle has focused on the political dimensions of Pareto's work[249], it was the methodological dimensions of the *Trattato* that mattered most to Henderson and his contemporaries at Harvard.[250]

Historian Joel Isaac has argued that the exclusive group of Pareto adherents—participants in the Pareto seminar and Sociology 23—at Harvard is best understood as a network of people

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[247] HBS, LJH Papers, Carton 3, Folder 3-5, Letter from LJH to Sorokin December 29, 1933.

[248] Ibid.

[249] A number of sociologists and a few historians have written about the Pareto circle and the political implications of Pareto's work. These studies primarily aim to track the "impact" of Pareto on American sociological thought. Representative examples include: Annie L. Cot, "A 1930s North American Creative Community: The Harvard 'Pareto Circle,' *History of Political Economy* 43, no. 1 (2011): 131-159; Barbara S. Heyl, "The Harvard "Pareto Circle," *Journal of the History of the Behavioral Sciences* 4, no. 4 (1968): 316–334; Robert T. Keller, "The Harvard" Pareto Circle" and the Historical Development of Organization Theory," *Journal of Management* 10, no. 2 (1984): 193-203.

[250] Joel Isaac, "The Harvard Pareto Circle revisited" (paper presented at the Seminar in Political Thought and Intellectual History, University of Cambridge, Cambridge, UK, October, 2008).

rather than a closely linked circle. The Pareto network, in Isaac's account, is a collection of institutional channels through which Henderson and his colleagues were able to disseminate Paretian social theory.[251] The main channels include: Henderson's course on concrete sociology, his work at the Harvard Business School, the Society of Fellows, and the Pareto seminar. These four channels make up, Isaac argues, a crucial part of the interstitial academy of the inter-war years. As Henderson noted in his letter to Sorokin, these were opportunities for people from across different disciplines to come together to discuss common problems of scientific methodology in the study of social life. In other words, the Pareto network provided the institutional space for up-and-coming social scientists to develop a new way of studying social life. This new approach would come to be known as structural-functionalism in the post-World War Two period. Sociologists like Talcott Parsons, George Homans, and Roethlisberger, used Pareto's social system as a "scientific" framework to explain a wide range of social phenomena. The work produced by the Pareto network dominated the intellectual agenda of sociology for decades after Henderson's death.[252] Despite his utter lack of training in Sociology, Henderson's reputation as "the arch exponent at Harvard of what made science science" made it possible for him to teach a course outside of his sphere of expertise. [253] At a time when the boundaries between the natural sciences and the social sciences were only just beginning to crystallize

[251]Ibid., 69.

[252] Some of the most influential works produced by Harvard Pareto seminar participants include: Talcott Parson's *The Structure of Social Action* (1937), Crane Brinton's *The Anatomy of Revolution* (1939), Chester Barnard's *The Functions of the Executive* (1938), Elton Mayo's *The Human Problems of an Industrial Civilization* (1933), and Fritz Rothlisberger and W. J. Dickson's *Management and the Worker* (1939).

[253] Quoted in Isaac, *Working Knowledge: Making the Human Sciences From Parsons to Kuhn* (Cambridge, MA, 2912), 65.

Henderson was able to take advantage of his prominent position at Harvard to influence a generation of social theorists.

By the mid-1930s, the informal gatherings evolved into Sociology 23, a course in the official Harvard College course register. Originally entitled "Seminary in Methods and Results of Certain Sociological Investigations," the course would later be known as simply "Concrete Sociology: A Study of Cases."[254] Using the "case method"—originally developed at the Harvard Law School in 1870 by Christopher C. Langdell—as a mode of instruction, Henderson enlisted the help of Pareto Seminar participants—Brinton, Homans, Parsons, Mayo, Devoto, Lowell, Barnard, Whitehead, and Roethlisberger. Henderson claimed that studying cases is the next best thing to studying something directly because it allows the student to "observe first-hand the effect of first hand familiarity with events that is manifested by the lecturers in the presentation of their cases."[255] Each case was therefore presented by "a person who has himself been involved in the event, or who has intimate first-hand knowledge of the event, or who is a specialist long and intimately familiar with a professional discipline which sharpens his perceptions and heightens his understanding of the event."[256] Both the Pareto seminar and Sociology 23 were aimed at demonstrating applicability of the concept of the social system, as a conceptual scheme, to the study of human relations.

The cases came from a variety of fields, including politics, industry, the practice of law and medicine, family and student life, history and religion, but all conformed to Henderson's definition of sociology as the science of the study of interaction between persons. The cases

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[254] Isaac, *Working Knowledge*, 70.

[255] Henderson, "Sociology 23: Introductory Lectures," 3.

[256]Ibid.

were intended "to elucidate some of the most general uniformities in the interactions between persons."[257]

By 1937—the second time he taught the course—Henderson was confident that this way of treating the uniformities in interactions between people was "sufficiently extensive to serve not only the needs of sociologists, but also those of historians and political scientists, as well as of men who practice the professions or engage in business."[258] By the end of the course, a diligent student would have assimilated and internalized Henderson's social system as his or her own framework for the study of interactions between persons. Henderson continued to teach Sociology 23 until 1939. By 1941, he became "seriously concerned about the arrangements for the future of the Fatigue Lab…as well as the Pareto seminar and Sociology 23."[259] He noted to Chester Barnard that it looked as though he "should have to spend a good deal of time…protecting what has been built up."[260] Henderson was correct, both the HFL and Sociology 23 were discontinued after his death. However, the social system lived on in the works of the Pareto seminar participants.

Henderson defined sociology as "the science that is conversant with a certain class of phenomenon," more specifically, "the interactions between persons."[261] In defining sociology this way, Henderson was, on the one hand, extending the discipline's relevance to a variety of fields, including medicine; on the other, he limited its analytic focus to observable human

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[257] Ibid.

[258] Ibid.

[259]HBS, Chester I. Barnard papers, Cart 2, Folder 51, letter from LJH to Barnard dated August 5, 1941.

[260] Ibid.

[261] Ibid.

behavior (including what people say). By identifying interactions between persons as the primary unit of analysis, he opened the door to making phenomena that were once invisible and therefore beyond the scope of analysis suddenly relevant to social science. Nevertheless, Henderson reminded his students that his definition was, like all definitions, and within limits, "arbitrary." "The test of a definition," he states, "is its convenience."

It was this conception of the social and of sociology that Henderson was referring to when he wrote about the "half-forgotten sociological aspects of medical practice."[262] Even so, Henderson's path—via Pareto—was not the only route to seeing the practice of medicine as a form of social interaction. Henderson's writings on the doctor patient relationship were a part of a well-developed discourse about social medicine, especially well-developed in Boston. In his articles "Doctor and Patient as a Social System" and "Medicine as Applied Sociology," one finds themes that resonate with the writings of other physicians of his time. The notion that practitioners ought to consider the social factors that affect their patient's lives was not unique to Henderson. Richard Cabot, for example, was well known as an advocate for the importance of the social and spiritual dimensions of a sick person's life.[263] Like Henderson and Alfred Worcester, he believed that physicians were beginning to drop their traditionally broad attention to the multiple factors that contribute to a person's illness and health.[264] Unlike Henderson, however, Cabot maintained that physicians should delegate responsibilities for the personal,

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[262] Lawrence Joseph Henderson, "The Practice of Medicine as Applied Sociology," *Transactions of the Association of American Physicians* 51 (1936): 10.

[263] Christopher Crenner, *Private Practice In the Early Twentieth-Century Medical Office of Dr. Richard Cabot* (Baltimore: Johns Hopkins University Press, 2005): 77; Alfred Worcester, "Past and Present Methods in the Practice of Medicine," *Boston Medical and Surgical Journal* 176, no. 5 (1912): 159-164.

[264]Ibid.

spiritual, and social dimensions of healing to social workers, counselors, and clergy.[265] Like other progressive reformers of his day, Cabot "saw a solution to the chaos of modern, urban life in the power of organized expertise."[266] As the founder of first American hospital based department of social work at Massachusetts General Hospital in 1905 he was a major supporter of professional medical social workers.

Henderson, on the other hand, argued that these—attending to the social factors in clinical practice—responsibilities could not be outsourced to other professions. He argued that there were limits to the extent to which medicine could outsource this responsibility. "Social service [*sic*] so called is in some measure an attempt to take over a part of the physician's office that he has forgotten or abdicated, but it is concerned only with a fragment of the forgotten task. And even when it is not vitiated by sentimentality and by ethical dogmatism it can be no full substitute for the well rounded work of the wise physician."[267] For Henderson, a fundamental part of medical practice was understanding and attending to the personal and social needs of the patient. To be responsible in medicine was to be attentive to the personal and social needs of the patient. He was critical of the division of labor that was taking place in the medical profession and proposed that doctors be trained to "understand and treat real men and women, not mere medical, surgical or social cases."[268] In the words of Henderson, "there is need to fix and clarify the ideas of physicians concerning the half-forgotten sociological aspects of medical practice and

[265] Ibid.

[266] Ibid., 78.

[267] Henderson, "The Practice of Medicine," 10.

[268] Ibid.

to give appropriate instruction to medical students, for here no more than a partial division of labor is possible."[269]

Much like Henderson and Cabot, Hopkins trained physician and medical educator, George Canby Robinson, believed in the importance of grounding medical education in scientific training. Robinson advocated for the study of the social aspects of illness as a core part of medical training.[270] Both Henderson and Robinson maintained that the complex problems of human disease were uniquely encountered by the medical profession. The solution to these problems, he argued, "cannot be left to workers in other fields."[271] Robinson insisted that the patient must be seen as "a person," the context in which a patient lives his/her life. Based on evidence collected from a series of home visits, Robinson concluded that "emotional and social problems disturb the health of a large proportion of the patients admitted to the medical service…and that they [emotional and social problems] frequently constitute the major cause of illness."[272] Addressing the emotional and social factors in medicine required that students be trained "from the beginning of their clinical experience to consider every patient as a person."[273] Just how students might be trained to consider the patient as a person was not clearly articulated by Robinson.

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[269] Ibid.

[270] George C. Robinson, *Patient as a Person* (New York, NY, 1939)

[271] George C. Robinson, "The Application of Science to the Practice of Medicine," *Science* 69, no. 1792 (1929): 461.

[272] George C. Robinson, "Proper Attention to the Role of Emotional and Social Factors in Illness as a New Step in Public Health," The *Milbank Memorial Fund Quarterly* 23, no. 1 (1945): 21.

[273]Ibid., 26.

Equally concerned about the importance of the care of the patient and the physician-patient relationship was the Boston based physician, Francis W. Peabody. "The significance of the intimate personal relationship between physician and patient," he wrote in 1927, "cannot be too strongly emphasized, for an extraordinarily large number of cases both diagnosis and treatment are directly dependent on it."[274] The failure to establish this relationship, he went on, "accounts for much of his [the physician's] ineffectiveness in the care of patients."[275] For all of the above mentioned physicians, the physician-patient relationship was just as crucial a component of good care as modern diagnostics and therapeutics.

In the 1920s and 1930s, the growing attention to the importance of the doctor-patient relationship as well as the social and emotional factors that affect health gave rise to curricular innovations in medical education aimed at encouraging a more preventive approach to health.[276] This turn towards preventive medicine and attention to social factors is commonly associated with social medicine and public health. In a recent article, historian of medicine, Dorothy Porter describes the evolution of social medicine as an academic discipline and its links to political conceptualizations of the role of medicine in society.[277] She argues that in the inter-war years, medical reformers saw social medicine as a way to integrate medicine's social role into the training of physicians. Inspiration for this new vision of social medicine's potential came out of

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[274] Francis W. Peabody, "The Care of the Patient," *Journal of the American Medical Association* 88 (1927): 878.

[275] Ibid.

[276] Jane Pacht Brickman, "Science and the Education of Physicians: Sigerist's Contribution to American Medical Reform," 15, no. 2 (1994): 145.

[277] Dorothy Porter, "How Did Social Medicine Evolve, and Where Is It Heading?," *PLoS Med 3*, no. 10 (October 24, 2006): e399.

experiments in social hygiene in revolutionary Russia in the 1920s.[278] Advocates of social medicine—such as Henry Sigerist—believed that social science could provide a sociopolitical role for medicine.

This more politically charged view of the role of the social sciences in medicine differed from Henderson's account of medicine as applied sociology. Henderson instead wanted to bring the methods and values of physiology and biochemistry to create a rigorous (more than empirical Hippocratic) way of studying and improving the mini-social system that constituted the doctor-patient relationship. In Henderson's work, we find a combination of intellectual perspectives that are genuinely unique. Alongside Pareto and Frederick Shattuck, Henderson references the work of Machiavelli, Emile Durkheim, and Lord Chesterfield. In all of these works he found support for his conviction that human sentiments are often more important in determining the future of human events than reason. He references the work of Chester Barnard, the President of the New Jersey Bell Telephone Company, on logical and non-logical thought to illustrate his point about the tendency of patients to unintentionally read meaning into statements made by physicians what is not intended. Just as in business, a patient "sitting in your office," Henderson explains, "is rarely in a favorable state of mind to appreciate the precise significance of a logical statement."[279] Here again Henderson finds additional support for his claim that the sentiments are indeed the most important forces in social interaction. Combined, these influences gave rise to Henderson's conception of sociology as a science of human relations that could be studied using the same methods used in the physical sciences and Pareto's concept of the social system.

[278] Ibid.

[279] Henderson, "The Practice of Medicine," 16.

Disciplinary Formation and Medical Education

Henderson's efforts to redefine sociology took place against a background of a rapidly changing university structure. The institutionalization of the social sciences in American universities began in the period between the late nineteenth century and the early twentieth century.[280] The leading figures of twentieth century American sociology and social theory had eclectic backgrounds. For example, Albion W. Small, founder of sociology at the University of Chicago (1892), was trained in theology, German history, and politics. Harvard's Talcott Parsons had a background in philosophy, biology, and economics. Others like George H. Mead and Robert Park had strong foundations in philosophy and psychology. Similarly, changes in institutional structures for medicine—the hospital, for example, was becoming an increasingly important site for practicing medicine, training doctors, and receiving care.[281] The 1920s through the 1940s was an intense period of disciplinary formation and professionalization at American universities.[282]

Disciplinary politics at Harvard mirrored these larger national trends. Harvard grew tremendously between 1900 and 1933, adding the iconic residential housing system for undergraduates, Widener library, Memorial church, the T. Jefferson Coolidge, Jr. Memorial Laboratory, three million dollars were invested in the construction and maintenance of chemical

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[280] Dorothy Ross, *The Origins of American Social Science* (New York, NY, 1991).

[281] Charles E. Rosenberg, *The Care of Strangers: The Rise of America's Hospital System* (Baltimore, MD, 1995).

[282] Writings on the modern university include: Julie Reuben, *Making of the Modern University: Intellectual Transformation and the Marginalization of Morality* (Chicago: University of Chicago Press, 1996); Roger L. Geiger, *To Advance Knowledge: The Growth of American Research Universities, 1900-1940* (Oxford: Oxford University Press, 1986).

laboratories to replace Boylston Hall, a new fund was created by the Harvard Corporation for the maintenance of research and campus buildings, and the Harvard Graduate School of Business Administration and the Harvard School of Public Health were both established during this period of expansion.[283] During this period of institutional growth at Harvard, disciplinary identities were forged in the interstitial spaces—underinstitutionalized academic spaces—that provided opportunities for scholars to ask questions about scientific epistemology, research practice, and pedagogy.[284]. This was the context in which Henderson was attempting not only to create sociologists, but also to disseminate his vision of a transdisciplinary approach for the scientific study of social life. The fact that he was even trying to achieve this goal points to the moving boundaries between the social and the natural sciences at American research universities in the 1930s.

The fact that medical educators were so interested in Henderson's approach to sociology of medicine suggests that the medical profession, too, was still trying to define itself.[285] Charles Rosenberg and other historians of American medicine have documented the dramatic changes in

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[283] Samuel Eliot Morison, *Three Centuries of Harvard, 1636-1936* (Cambridge: Harvard University Press, 1942); Clark A. Elliott and Margaret W. Rossiter, ed., *Science at Harvard University: Historical Perspectives* (Bethlehem, PA: Lehigh University Press, 1992).

[284] Isaac, *Working Knowledge*, 6.

[285] Numerous articles citing Henderson's work on the physician patient relationship as a social system appeared in leading medical journals, see Kenneth J. Tillotson, "Psychobiology in General Medicine," *The New England Journal of Medicine* 215, no. 4 (1936): 146-149; "Notices and Meetings," *New England Journal of Medicine* 213, no. 21 (1935): 1051-1052; W. Eliasberg, "The Social Implications of Dysphasia," *The Journal of Nervous and Mental Disease* 105, no. 5 (1947): 465-476; "Testimonial Dinner and Meeting in Honor of Dr. David L. Edsall," *The New England Journal of Medicine* 213, no. 17 (1935): 836; Charles C. Lund, "The Doctor, the Patient, and the Truth," *Annals of Internal Medicine* 24, 6 (1946): 955-959; George R. Minot, "The President's Address," *Transactions of the Association of American Physicians* 53, (1938): 1-6; George R. Minot, "Investigation and Teaching in the Field of the Social Component of Medicine," *Bulletin of the American Association of Medical Social Workers* 10, no. 2 (1937): 9-18; George R. Minot, "Medical Sociological Aspects in Practice," *Archives of Internal Medicine* 54, no. 1 (1934): 1-10; George P. Reynolds, "The Teaching of the Medicosocial Aspects of Cases," *The New England Journal of Medicine* 220, no. 1 (1939): 1-7.

the social organization of medicine underway during this time, from the proliferation of hospitals, professionalization of public health, and the growing emphasis of the natural sciences in medical schools.[286] These developments, combined with the emergence of the modern university in the United States in the late nineteenth century and the influx of funds from philanthropic organizations, gave rise to a more rigorous and academically oriented medical education. One consequence of this change was the creation of a more standardized and formal system of training young doctors. Although medicine was well-established and well-respected by the American public in the 1930s, there was growing specialization and fragmentation within the profession.[287]

An enduring tension within medicine exists between a more contextualized view of clinical realities—antireductionist positions often associated with social medicine and public health—and a reductionist view that treats disease primarily as a mechanism.[288] Contemporary

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[286] Rosenberg, *The Care of Strangers*; Rosenberg, *Explaining Epidemics and Other Studies in the History of Medicine* (Cambridge, England, 1992), 215-242; Paul Starr, *The Social Transformation of American Medicine* (New York, NY, 1982): 79-144; Kenneth M. Ludmerer, *Learning to Heal: The Development of American Medical Education*, (New York, 1985): 47–71; Morris J. Vogel, *The Invention of the Modern Hospital, Boston, 1870-1930* (Chicago, IL, 1980). For a history of Harvard medical school see, Mark D Altschule and Henry K Beecher, *Medicine at Harvard: The First Three Hundred Years* (Hanover, N.H, 1977). For a review of the impact of science in medicine see, John Harley Warner, "Science in Medicine," in *Historial Writings in American Science: Perspectives and Prospects*, ed. Sally Gregory Kohlstedt and Margaret W. Rossiter (Baltimore, MD, 1985), 37-58.

[287] Rosemary Stevens, *Medical Practice in Modern England: the Impact of Specialization and State Medicine* (New Haven, CT, 1966); Ludmerer, *Learning to Heal*; George Weisz, *Divide and Conquer: A Comparative History of Medical Specialization* (Oxford, England, 2005).

[288] For a discussion of this tension within American Medicine and in Europe see, Sarah Tracy, "An Evolving Science of Man: The Transformation and Demise of American Constitutional medicine, 1920-1950," in *Greater Than the Parts; Holism in Biomedicine, 1920-1950*, Christopher Lawrence and George Weisz, eds. (Oxford: Oxford University Press, 1998): 161-188; Sarah Tracy, "George Draper and American Constitutional Medicine, 1916-1946," *Bulletin of the History of Medicine* 66, no.1 (1992): 53-89; Charles Rosenberg, "Holism in Twentieth-Century Medicine," in *Greater Than the Parts; Holism in Biomedicine, 1920-1950*, Christopher Lawrence and George Weisz, eds. (Oxford: Oxford University Press, 1998): 335-336; Charles E. Rosenberg, *Our Present Complaint* (Baltimore: Johns Hopkins

commentators and historians have disagreed as to whether Henderson might best be described as a holistic thinker or a "reductionist" physical scientist. During Henderson's life, one of his fiercest critics was J. B. S. Haldane, who saw in Henderson's magnum opus, *Blood*, a reductionist tract.[289] Another contemporary, Yandell Henderson, argued that Henderson was a scientist turned metaphysician.[290] Historians of science, in contrast, have tended to focus on Henderson's holistic thinking. John Parascondola, for example, identifies "organismic thought" in Henderson's many published works.[291]

Any attempt to claim Henderson as a holist misunderstands his work on a fundamental level. Henderson was a thoroughgoing reductionist. In his first book, *The Fitness of the Environment* (1913) Henderson expresses his views on mechanistic nature of life:

> …such conclusions depend upon the universal character of physics and chemistry. Out of the properties of universal matter and the characters of universal energy has arisen mechanism, as the expression of physico-chemical activity and the instrument of physico-chemical performance. Given matter, energy, and the resulting necessity that life shall be a mechanism, the conclusion follows that he atmosphere of solid bodies does actually provide the best of all possible environments for life.[292]

As discussed in Chapter two, Henderson saw the fitness of the environment for life as undeniable evidence that life can be described, in physico-chemical terms, as a system—a known set of

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University Press, 2007): 139-165; Ann Harrington, "Metaphoric Connections: Holistic Science in the Shadow of the Third Reich," *Social Research* 62, no.2 (1995): 357-385.

[289] Haldane also accused Henderson of completely misinterpreting Claude Bernard's philosophy of the organism. For more on Haldane's critique of Henderson see J.S. Haldane, "Claude Bernard's Conception of the Internal Environment," *Science* 69, no. 1791 (1929): 453-454.

[290] Yandell Henderson, "Is This Science or Metaphysics?," *Science* 69, no. 1778 (1929): 39-41.

[291] Interpreting Henderson's work as a whole, John Parascondola concludes that Henderson was an organicist. See Parascandola, "Organismic and Holistic Concepts in the Thought of L. J. Henderson," *Journal of the History of Biology* 4, no. 1 (1971): 63-113. Sarah Tracy's account of constitutionalism in mid-century American medicine also identifies strands of holistic thinking in Henderson's work on the doctor-patient relationship. See Tracy, "An Evolving Science".

[292] Lawrence J. Henderson, *The Fitness of the Environment* (New York: Macmillan, 1913): 272.

variables whose interrelations could be formally stated using symbolic logic and mathematics. In his second book, *The Order of Nature* (1917), he argues that organization and order are important concepts for understanding life. Despite the underlying mechanistic nature of life, in other words, it is additionally necessary to perceive pattern and order to advance our scientific understanding of life. Yet his two published book and a numerous articles reveal that he was in fact committed to a mechanistic conception of life.[293] He did not believe, in any way, that the whole was greater than the sum of its parts. For him it was a matter of refining and improving theory through experimentation.

Henderson's reductionism almost certainly can be traced to his training in physical chemistry as an undergraduate at Harvard College, from 1894-1898. He spent the first quarter of his career studying the physical properties of chemical substances before moving on to the study of acid-base equilibrium toward the end of his medical school career. Before long, Henderson had undergone a transformation from chemist to physiologist, but he still did not have contact with patients. It was only because his medical colleagues could supply him with the raw materials—mainly blood and urine samples—necessary to conduct his physico-chemical studies that Henderson had contact with colleagues who had any direct contact with patients in clinics and hospitals at all.

And yet: despite his limited experience in the clinic and the abstract nature of his own scientific work, when it came to medicine he believed in "using clinical observation as the basis for further clinical procedure."[294] Ironically, Henderson was speaking not from first-hand experience, but from a theoretical commitment to the importance of first-hand observation in

[293] Henderson's first two books are discussed at length in chapter two.

[294]HBS Archives, LJH Papers, Carton 1, Folder 29, letter from LJH to to W.B. Cannon, October 03, 1917.

scientific research. Henderson's goal was to describe a method of studying social interaction—both within and beyond the clinic.

Henderson's commitment to a scientific, reductionist understanding of human social interactions is the key to explaining the apparent contradiction between his reductionist approach to the life sciences and his supposedly holistic approach to medicine—really, it's not holistic at all. Henderson believed that, rather than being an art; the doctor-patient relationship could be studied scientifically. During the last fifteen years of his life, Henderson devoted all of his intellectual energy to the study of the *social organism* which, like the human organism, might be understood as a *mechanism*.

In the first decades of the twentieth century physicians were trying to come to terms with the implications of this new mechanistic conception of life and disease as well as the introduction of new medical technologies, laboratory science, and the changing social organization of medicine. For some, the introduction of such new therapies and diagnostic technologies in the early twentieth century helped to reaffirm, rather than diminish, the importance of the relationship between doctor and patient. As one perceptive observer noted, "it seems as though medicine were for the time being more or less in the grip of science, at the same time struggling to maintain its great heritage as the most humane of the professions."[295] Others opined that modern medical schools had been "Carried away by the brilliance of etiological discoveries" and had subsequently failed to teach students the "therapeutic value of sympathy and encouragement."[296] Among those defending the preservation of a humanistic tradition in

[295] Ida M. Cannon,"Teaching Medical Students the Social Implications of Sickness," *New England Journal of Medicine* 211, no. 5 (1934): 216.

[296]Alfred Worcester, "Past and Present," 164.

medicine was George Minot, who in his 1938 address of the Association of American Physicians, reminded his audience that "in order to understand the present, we must look both toward the past and toward the future." He urged the men in the audience to take "advantage of every available bit of information and study of greater knowledge so that when we pass the torch to the other generation it will be nearer to the ultimate goal." This forward movement, he added, "may be profitably combined with an effort to transmit to posterity all that was best in the past."[297] Even those who embraced the new developments in science felt that there were still things to be learned about the past. The challenge was in figuring out which things should be preserved, how to preserve them, and how to combine them with new developments to improve care.

Henderson and some of his contemporaries were especially concerned with preserving what they referred to as "the social component of medicine." The critique of the cold and impersonal nature of medical science was, in the early decades of the twentieth century, taking its now familiar form. This critique would, in the politically and charged decades of the 1960s and 1970s, become a social critique of the "objectifying" power of medical science.[298] But in the first third of the twentieth century, a host of medical scientists and practitioners, including Henderson, hoped to use scientific medicine to improve the lives of patients while finding some balance between bedside care and the laboratory. Many of the mentioned in the previous

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[297] George R. Minot, "The President's Address," *Transactions of the Association of American Physicians* 53 (1938): 1-6.

[298] Thomas S. Szasz, *The Myth of Mental Illness: Foundations of a Theory of Personal Conduct* (New York: Hoeber-Harper Press, 1961); Erving Goffman, *Asylums: Essays on the Social Situation of Mental Patients and other Inmates* (Garden City, NY: Anchor Books, 1961); Michel Foucault, *Madness and Civilization: A History of Insanity in the Age of Reason*, trans. Richard Howard, (New York: Vintage, 1965).

section, appeared to share the belief that the "authority" of medicine, and indeed the profession itself, depended upon medicine's proper care of, and relations with, the patient.

People outside of medicine proper were also part of these conversations on the future of medicine, through their participation in philanthropy and government agencies. A number of scholars from the nascent field of medical economics and public health, including Isidore Sydney Falk, J. Douglas Brown, and Charles-Edward Amory Winslow, were conducting research on the social aspects of medicine, socialized medicine, and the relationship between medicine and the state.[299] One particularly fraught issue was the question of how to fund healthcare for the general population. The Committee on the Costs and Means, funded by large philanthropists, employed dozens of economists and a few willing physicians to conduct a national survey on the cost of care in various hospitals. Henry E. Sigerist, director of the Johns Hopkins Institute of History of Medicine from 1932–1947, was an important figure in the socialized medicine movement and pioneer in the social history of medicine.[300] Sigerist's research on socialized medicine in the Soviet Union sought ways to apply some of the insights of socialized medicine in the U.S. The major philanthropic funds and foundations, including the Carnegie Institute, the Rockefeller Foundation, the Commonwealth and Milbank Funds, and the Russell Sage Foundation all carried out large-scale studies on financing healthcare.

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[299] Falk is best known for his role as director of the Committee on Cost of Medical Care and head of health studies for the Social Security Administration in the mid-1930s. For an overview of Falk's views on the problem of health care provision see I. S. Falk, "An Introduction to National Problems in Medical Care," *Law and Contemporary Problems* 6, no. 4 (1939): 497-506. J. Douglas Brown is considered remembered as one of the principle architect of the Social Security System see Brown, "The Development of the Old-Age Insurance Provisiosn of the Social Security Act," *Law and Contemporary Problems* 186 (1936): 186-198. Charles-Edward A. Winslow was a bacteriologist, public health expert, and founder of the Yale Department of Public Health. He was an advocate for a broad range of public health measures in the United States and Europe see Winslow, *The Evolution and Significance of the Modern Public Health Campaign* (New Haven, CT: Yale University Press, 1923).

[300] See Henry E. Sigerist, *Socialized Medicine in the Soviet Union* (New York: W.W. Norton, 1937).

Unlike some of his contemporaries who either believed in an inherent antagonism between the science and art of medical practice, or others who sought to establish a division of labor between the two, Henderson advocated for a more scientific approach to the study of human relations in medicine. Henderson's conceptual scheme combined elements of the Hippocratic method with continental social theory. By taking Henderson's writings and project seriously, we can see the making of the boundaries between the biological and the social. Henderson offered his medical colleagues a means of making the heart of medical practice—the human relations that make medicine distinct from laboratory science—scientific.

Although Henderson never practiced medicine, he spent years educating young physicians first as an instructor, and later as a professor, of physical chemistry and physiology at the Harvard Medical School. He was in some ways always connected to medical practice. He was elected to the Association of American Physicians in 1922. And of course, he was at various points in his life, a patient. But more to the point, unlike many of his contemporaries, he did not think that personal relations were beyond scientific analysis.

Attention to the social was on the minds of some of the leaders in medicine and medical education. Elite centers of medicine, such as Massachusetts General Hospital (MGH) and Johns Hopkins Hospital, were leading efforts to address the social components of medical care. It was in this context—where attention to the social factors affecting health became so important—that Henderson's conception of the social system appealed to a broad audience ranging from social scientists to medical practitioners. Henderson offered a depoliticized and scientific method of studying social interactions.

A Science of Human Relations

Henderson's legacy in medical schools and at Harvard is mixed. He did not leave an obvious historical footprint. His work, however, on the physician-patient relationship is often cited as evidence for the importance of sociological factors in clinical practice. [301] In spite of Henderson's influence in medicine, more recent work by medical sociologists have paid almost no attention to his articles on the sociological aspects of medical practice. One reason for this is that Henderson was a scientist, not a sociologist. As sociology became more prominent and established in the university, writing the history of sociology became an act of delineating a genealogy of contributions and thought of the discipline. Henderson is treated—at best—as a minor footnote in these disciplinary histories. After the eclipse of Parsons and his intellectual project, structural functionalism, as a school of thought, the likelihood of considering Henderson's texts in their historical context became even more remote. In sociology and medicine, there continues to be a divide between what is considered a social question and what is considered a medical question. Henderson's work was different in that he emphasized the importance of "social interaction" as part of a scientific system rather than a political or

[301] Years later, physicians and researchers continued to site Henderson's articles on the physician patient relationship. Web of science indicates that Henderson's article on the physician patient relationship as a social system is cited 1110. Here are a few of the more prominent sitations to illustrate the diverse range of contexts in which Henderson's work on the physican patient was cited in the post-war period: Bo Gerle, Gerd Lunden, and Philip Sandblom, "The Patient with Inoperable Cancer from the Psychiatric and Social Standpoints," *Cancer* 13, no. 6 (1960): 1206-1217; Robert H. Heptinstall, "Ivory Tower Humanist," *The New England Journal of Medicine* 289, no. 16 (1973): 862-863; Talbott, "At the Bedside," 109-114; Herman L. Blumgart, "Caring for the Patient," *The New England Journal of Medicine* 270, no. 9 (1964): 449-456; Abraham J. Simon, "Social Structure of Clinics and Patient Improvement," *Administrative Science Quarterly* 4, no. 2 (1959): 197-206; Mark G. Field, "Some Problems of Soviet Medical Practice: A Sociological Approach," *The New England Journal of Medicine* 248, no. 22 (1953): 919-926; Robin F. Badgley and Samuel W. Bloom, "Behavioral Sciences and Medical Education: The Case of Sociology," *Social Science and Medicine* 7 (1973): 927-941; Robert W. Habenstein, "Critique of "Profession" as a Sociological Category," *The Sociological Quarterly* 4, no. 4 (1963): 291-300; Paul L. Adams, "The Influence of New Information from Social Sciences on Concepts, Practice and Research in Child Psychiatry," *Journal of the American Academy of Child Psychiatry* 21, no. 6 (1982): 533-542.

economic system. He offered social scientists and medical practitioners a new way of conceptualizing the interactions that take place in everyday life.

CHAPTER FOUR

The Industrial Workplace as a Social System

Chapter Four examines the Harvard Fatigue Laboratory (HFL), a physiological laboratory dedicated to understanding the impact of the physical and social environment on "normal" individuals. This chapter focuses on two types of studies conducted by the HFL that illustrate how Henderson's theory of systems was applied to the study of work. The first is the well known Hawthorne Studies and the second is what I shall refer to as the Hot Climate Study. Each example highlights the way physiology and social theory were used to gain a new understanding of the workplace as a physical and social environment.

Henderson was the official director of the Fatigue Lab from its inception in 1927. Although he was the official director, Henderson did not directly engage in laboratory work or field studies. Instead, his influence was primarily intellectual. Much of the work conducted by the HFL was dedicated to providing evidence in support of Henderson's social theories regarding the dynamics of social control, social organization, and social equilibrium. This was perhaps most prominently seen in the so-called Hawthorne studies lead by Elton Mayo. This chapter follows Henderson's ideas and influence beyond the laboratory, clinic, and into the industrial workplace. It looks specifically at the ways in which social systems theory was applied to the study of human interactions on the factory floor. Located at the Harvard Business School, the Harvard Fatigue Lab was home to physiologists, sociologists, psychologists, and anthropologists. People such as Wallace Donham (Dean of HBS), Chester Barnard (business executive), and Elton Mayo were convinced that a deeper understanding of the underlying physiological, psychological, and social changes that mark an individual's everyday life would yield answers to the day's most vexing business and managerial problems.

To today's readers, it may seem a bit puzzling that the Fatigue Laboratory, a physiological facility, was established at the Harvard Business School. A more obvious choice might have been the medical school or the School of Public Health. At the time, however, these institutions were committed primarily to the study of prevention or treatment of disease. The Harvard Fatigue Laboratory, in contrast, focused on the normal rather than the pathological. In fact, the Fatigue Lab was focused on providing a more robust qualitative and quantitative distinction between normal and pathological physiological states. As philosopher Georges Canguilhem states in the introduction of his book, *The Normal and the Pathological*, governing disease is predicated upon becoming "acquainted with its relations with the normal state."[302] Canguilhem explains that in order to establish a pathology scientifically, one must link it to physiology. In other words, Canguilhem argues, "identity of the normal and the pathological is asserted as a gain in knowledge of the normal."[303] Normal and pathological exist along a spectrum, they are in the words of Claude Bernard, homogenous with one another. For Henderson and his colleagues at the Harvard Fatigue Lab, the goal was to first establish a physiological baseline, a statistical norm against which physiological disruption or deviation could be measured. Whereas Henderson's contributions to medical sociology might be considered a conceptual bridge between the laboratory and social life, the Harvard Fatigue Lab serves as an example of an institutional bridge between the laboratory and social life. Social life, in this case includes the workplace, the clinic, and all places in which human relations are acted out. One of this chapter's central arguments, then, is the idea that biological and social

[302] Georges Canguilhem, *The Normal and the Pathological* (New York: Zone Books, 1998): 41.

[303] Ibid., 43.

understandings of man became relevant to different communities of disciplinary practice for different reasons.

Existing histories of the Harvard Fatigue Lab have generally treated it as a rare and singular institution with a short life span.[304] I will treat it here instead as a particularly salient example of the range of early-twentieth-century research projects, funded largely by the Rockefeller Foundation, to study the impact of the physical and social environment on healthy individuals. Seen in this light, the HFL becomes a microcosm of a moment in time, rather than an anomaly. Examining the Harvard Fatigue Lab in this way shows a transdisciplinary desire on the part of Henderson and his contemporaries; an effort to cross boundaries and find a systematic way of studying people in their physical and social environments.

Public-Private Partnership: Funding the Harvard Fatigue Laboratory

In 1927 Henderson, with the generous financial support of the Rockefeller Foundation, set up the Harvard Fatigue Laboratory with the goal of developing much-needed quantitative and qualitative descriptions of the physiological experience of everyday life. In collaboration with the Department of Industrial Research at the Harvard Business School and medical staff at the Massachusetts General Hospital (MGH) and other area hospitals, the HFL's laboratory staff set out to study the experiences of individuals in their everyday environment, instead of the laboratory situations that typically informed physiological research.

The move beyond the laboratory and into the workplace was inspired largely by the needs of a rapidly changing industrial landscape and changes in labor practices. There was a growing

[304] Steven M. Horvath, *The Harvard Fatigue Laboratory: Its History and Contributions*, (Englewood Cliffs, NJ: Prentiss-Hall, 1973); Robin Scheffler, "The Fate of a Progressive Science: The Harvard Fatigue Laboratory, Athletes, the Science of Work and the Politics of Reform," *Endeavour* 35, no. 2-3 (2011): 48-54.

need, on the part of large organizations, to understand workplace dynamics and the factors contributing to worker "productivity". This area of study had long been dominated by economic theories that claimed that workers were primarily motivated by monetary compensation. Elton Mayo and others based at the HFL were interested in studying the so-called non-logical factors, the social factors that contributed to worker productivity and satisfaction. This became increasingly relevant in the depression years when more and more companies had to confront social unrest on the factory floor. The introduction of new methods of production, mainly the assembly line and automation, dramatically changed labor practices.[305] The late nineteenth century and early twentieth centuries were marked by profound changes in the nature and organization of work. Such technological developments as the development of control loop feedback mechanisms and sectional electrical drives altered the organization of the industrial workplace; waves of recent immigrants establishing roots in places like Chicago, New York, and Boston altered the cultural landscape.[306] The combination of a cheap labor force and rapid

[305] For a classic critique of the capitalist mode of production and the impact of technology and automation on workers see Harry Braverman, *Labor and Monopoly Capital*, (New York: Monthly Review Press, 1974); for an account of how this approach to manufacturing permeated social life see, John Jordan, *Machine-Age Ideology: Social Engineering and American Liberalism, 1911-1939* (Chapel Hill: University of North Carolina, 1994); Michael Burawoy, *Manufacturing Consent: Changes in the Labor Process Under Monopoly Capitalism,* (Chicago: University of Chicago Press, 1979).

[306]For a dated but still influential account of these changes see Herbert Gutman, "Work, Culture, and Society in Industrializing America, 1815-1919," *American Historical Review* 78, no. 4 (1973): 531-588. For more recent scholarship on social and labor history in the early twentieth century see Lizbeth Cohen, *Making a New Deal: Industrial Workers in Chicago, 1919-1939,* (Cambridge: Cambridge University Press, 1990); Gary Gerstle, *American Crucible: Race and Nation in the Twentieth Century,* (Princeton, NJ: Princeton University Press, 2001); Alice Kessler-Harris, *Gendering Labor History,* (Urbana: University of Illinois Press, 2006); J. Carroll Moody and Alice Kessler-Harris, *Perspectives on American Labor History: the Problems of Synthesis* (DeKalb: Northern Illinois University Press 1989); and Daniel E. Bender, *American Abyss: Savagery and Civilization in the Age of Industry,* (Ithaca, NY: Cornell University Press, 2010); David M Kennedy, *Over Here: The First World War and American Society,* (New York: Oxford University Press, 1980).

industrialization resulted in a string of labor disputes throughout the twentieth century.[307] Urban riots and strikes highlighted the need to improve working conditions as well as industrial relations. It is within this context that a growing number of scholars, institutions, and philanthropic agencies began to express an interest in the scientific study of man.[308] The scientific study of man is understood here as "the study of men as organisms, of their structures and functions, in sickness and in health, and of men as persons, in their activities and their interactions…the uniformities observable among men."[309] The existence of a "Department of Industrial Research" at Harvard is itself an indication of the desire to develop systematized knowledge on industrial practices, including industrial workers.

The Rockefeller Foundation, in particular, funded a number of initiatives on the study of man.[310] It should be of little surprise that the Rockefellers would have such a keen interest in

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[307] Alan Dawley, *Struggles for Justice: Social Responsibility and the Liberal State,* (Cambridge, MA: Harvard University Press, 1991); David Brody, *Steelworkers in America: The Nonunion Era,* (Urbana: University of Illonois Press, 1998); Thomas G Andrews, *Killing for Coal: America's Deadliest Labor War,* (Cambridge, MA: Harvard University Press, 2008).

[308] For a comprehensive and authoritative account of the development of the social sciences in the United States see, Dorothy Ross, *The Origins of American Social Science,* (Cambridge: Cambridge University Press, 1991). For an overview of the human sciences from the sixteenth century to the twentieth century see, Roger Smith, *The Norton History of the Human Sciences* (New York: W. W. Norton, 1997). A recent edited volume challenges and complicates our understanding of pre- and post-WWII development of the social sciences. Mark Solovey and Hamilton Cravens, eds., *Cold War Social Science: Knowledge Production, Liberal Democracy, and Human Nature,* (New York: Pallgrave MacMillan, 2012).

[309]Lawrence J. Henderson, "The Study of Man," *Science* 94, no. 2427 (1941): 1-10.

[310]For an account of the role of Rockefeller Foundation in funding important developments in medical science and medical education see, Robert E. Kohler, *Partners in Science: Foundations and Natural Scientists, 1900-1945,* (Chicago: University of Chicago Press, 1991). For an account of the Rockefeller Foundation's role in facilitating the emergence of modern molecular biology and promoting interdisciplinary cooperation through the distribution of grants and fellowships in inter-war period see, Lily E. Kay, *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology* (New York: Oxford University Press, 1993). A more recent account of the role of foundations on American Foreign Policy and America's rise to global hegemony see, Inderjeet Parmar, *Foundations of the American Century: The Ford, Carnegie, and Rockefeller Foundations in the Rise of American Power,* (New York: Columbia University Press, 2012).

mechanisms of social and biological control. After all, the Rockefeller Foundation earned its fortune on the new industrialization.[311] Rebecca Lemov argues that modern American social science could not have developed "without the concomitant rise of modern-day foundations and the goals that powered them."[312] Lemov notes that between 1922 and 1929 the Rockefeller Foundation distributed nearly $50 million in support of social science projects around the globe.[313] This funding was motivated by a desire to develop a comprehensive understanding of social life and human behavior. Historian Jack Pressman has argued that the Rockefellers believed that "the true power of science, as applied to human beings, lay not in the pursuit of isolated laboratory studies but in the dynamic integration of inward looking experimental research with the expansive vision of social sciences and even the humanities." [314] The foundation carefully targeted different universities according to the existing strengths and needs of the universities in question. This resulted in the creation of specialized centers at universities according to the funding patterns of the Rockefeller foundation. For example, Caltech became the premier center for molecular biology while the University of Chicago became the nation's most innovative social science research hub. In other words, the foundation was attempting to

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[311] The Rockefeller Foundation's contradictory roll as champion of science and privately funded organization is perhaps best illustrated in the foundation's public health campaigns abroad. Historian of medicine, Anne-Emanuelle Birn and Armando Solórzano write about how the RF's hookworm campaign in Mexico deployed science in order to drive business friendly policies in Mexico. Birn and Solórzano, "Public health policy paradoxes: science and politics in the Rockefeller Foundation's hookworm campaign in Mexico in the 1920s," *Social Science and Medicine* 49 (1999): 1197-1213.

[312]Rebecca Lemov, *World as Laboratory: Experiments with Mice, Mazes, and Men* (New York: Hill and Wang, 2005): 50.

[313] Lemov, *World as Laboratory*, 50.

[314] Jack Pressman, "Human Understanding: Psychosomatic Medicine and the Mission of the Rockefeller Foundation," in *Greater Than the Parts: Holism in Biomedicine, 1920-1950*, Christopher Lawrence and George Weisz, eds. (Oxford: Oxford University Press, 1998): 190.

create a network of coordinate and organize research centers in the social sciences and the life sciences.

The majority of scholarship on efforts to organize interdisciplinary research focuses on the growth of state funding following World War Two. However, as this chapter attempts to demonstrate, the effort to organize experimentation across a wide range of disciplines and experimental efforts can be traced to the interwar period and private sources of funding. Robert Kohler's book, *Partners in Science*, presents the most comprehensive account of the system of patronage in scientific research led by the Rockefeller Foundation and the Carnegie Corporation in the early- to mid-twentieth century. Kohler views these developments as part of "the inexorable trend toward large-scale organization."[315]

The scientific study of man served to bridge the gap between what was beginning to be called the pure and applied sciences.[316] Man in all of his concreteness was to be the measure of all things—*Homo mensura.* Nowhere is this more obvious than in the Rockefeller Foundation's various studies on industrial hazards. The Rockefeller Foundation's program managers identified the quest to understand the physiology of work as a top research priority. A number of historians have examined the Rockefeller Foundation's support for such research in biology, psychology, social sciences, and medicine; in general, their assessments have not been particularly generous. Scholars have criticized the Rockefeller Foundation for selfishly seeking to maximize scientific returns, preserving capitalism, and imposing a conservative American

[315] Kohler, *Partners in Science*, 369.

[316] Paul Lucier, "The Origins of Pure and Applied Science in Gilded Age America," *Isis* 103, no. 3 (2012): 527-536.

ideal of scientific research upon other countries.[317] Kohler is the exception, in that he argues that the system of scientific patronage that emerged in the inter-war years was far less bureaucratic than the "organization synthesis" suggests and that it retained the more personal spirit of nineteenth century institutions. He points out that compared to corporations and government organizations the Rockefeller Foundation was small and informal, focusing on individual scientists and creating a system of mentors.[318]

This chapter builds on some of Kohler's insights, but emphasizes the growing centrality of the scientific study of man in organizing and coordinating research in the life sciences, social sciences, and medicine. Kohler argues that the foundation managers attempted to impose their business methods onto academic research by emphasizing planning and functional organization. Business methods belong to a general category of techniques used to make, organize, and streamline organizations. In the 1920s and 1930s, however, managerial science and organizational theory was in its infancy. In the early decades of the twentieth century, most corporate managers lacked a language with which to describe what they did. Instead of arguing for the imposition of a corporate logic onto the university, this chapter argues that the very notion of institutional organization and management first emerged out of the various partnerships

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[317] For examples see, Anne-Emanuelle Birn, *Marriage of Convenience: Rockefeller International Health and Revolutionary Mexico* (Rochester, NY: University of Rochester Press, 2006); Marcos Cueto, "The Rockefeller Foundation's Medical Policy and Scientific Research in Latin America: The Case of Physiology," *Social Studies of Science* 20 (1990): 229-254; Marcos Cueto, "Science Under Adversity: Latin American Medical Research and American Private Philanthropy, 1920-1960," *Minerva* 35 (1997): 233-245; Marcos Cueto, "Visions of Science and Development: The Rockefeller Foundation's Latin American Surveys of the 1920s," in *Missionaries of Science*, Marcos Cueto, ed. (Bloomington: University of Indiana Press, 1994); Pnina Abir-Am, "The Discourse of Physical Power and Biological Knowledge in the 1930s: A Reappraisal of the Rockefeller Foundation's 'Policy' in Molecular Biology," *Social Studies of Science* 12 (1982): 341-382; Donald Fisher, "The Role of Philanthropic Foundations in the Reproduction and Production of Hegemony: Rockefeller Foundations and the Social Sciences," *Sociology* 17 (1983): 206-236; Donald Fisher, "American Philanthropy and the Social Sciences in Britain, 1919-1939; The Reproduction of a Conservative Ideology," *The Sociological Review* 23, no. 2 (1980): 277-315; Kay, *The Molecular Vision*.

[318] Kohler, *Partners*, 397.

Kohler so carefully documents. The focus was not so much on research productivity as a purely economic measure, but rather on attempts to scientifically define man through his social relations and physical environment.

It is clear that whatever one makes of RF's politics, most of their efforts focused on man as an integrated whole. The system of foundation patronage took man as the essential unit upon which formal industrial and research organizations ought to be based.

This ambitious effort to study man in his environment would require a degree of disciplinary and institutional coordination which had never been attempted before. The coordination was dependent upon the parallel development of the various sciences which were needed to study man in his environment—the physical sciences, life sciences, medicine, and social sciences alike. But moreover, fully integrating this knowledge would require a theory about the nature of coordination and organization: in other words, a conceptual scheme. An understanding of man in everyday life required more than the mere summation of parts. What was needed was knowledge of how these parts interact. Enter Lawrence J. Henderson.

Henderson's understanding of complex systems included the idea that man might be considered a system of integrated parts. The complex nature of the human organism required a piecemeal investigation. When considered as part of a larger system of organization, Henderson believed, these distinct pieces would shed light on Man as an organism. Understanding the whole required an understanding of the parts in relation to each other. One had to understand the forces that governed the interaction between the parts. The scientific study of man required both a description of the various activities of the human organism and the framework presupposed by those activities.

Henderson maintained that the scientific investigation of such complex problems could only be the product of the labors of many men, working skillfully in parallel and in succession, with shared methods, systematic descriptions, and classifications.[319] Henderson envisioned a scientific community composed of distinct disciplines, each with their own conventions and methods of investigation, united by a commitment to the verification of facts and the development of adequate conceptual schemes.

Henderson's commitment to developing scientific disciplines should not be confused with a notion of planned scientific progress, which he ardently opposed.[320] For Henderson, scientific progress could only proceed through trial and error and the adaptation of increasingly refined theories. Those scientific ideas that survive, Henderson argued, do so because they are adapted to the needs of scientists.[321] If theory became detached from need, it ran the risk of becoming disconnected from reality. It was through hands-on experience, practice, that disciplined physicians or scientists could submit their theories to more rigorous proof. Theory and practice had to be consistently combined to avoid the fallacy of misplaced concreteness—mistaking the abstract for the concrete.[322] Henderson believed that this tendency could be avoided through acquiring intimate, habitual, and intuitive familiarity with the object of study. This degree of hands-on experience with the object of study would, in Henderson's opinion, help

[319] Henderson, "The Study of Man," 4.

[320] For Henderson's critique of the belief in progress, be it scientific, technological, or social, see Henderson, "What is Social Progress?," *Proceedings of the American Academy of Arts and Sciences* 73, no. 15 (1940): 457-463.

[321] Henderson, "The Study of Man," 4.

[322] The concept of the fallacy of misplaced concreteness was developed by Alfred N. Whitehead in Whitehead, *Science and the Modern World*, (New York: Macmillan, 1925): 52.

the investigator avoid the trap of falsely conflating the abstract theory about the object and the object itself in all of its complexity.

Henderson's attempts to understand the concreteness of man as an organism fit perfectly with the practical interests of the Rockefeller Foundation in the sociology and physiology of work. The "physiology of work," as used here, describes the scientific study of the laboring body. Unlike pathophysiology which focuses on the diseased body, studies on the physiology of work sought to determine what could be reasonably expected of an average worker in different environments. The knowledge gained about the body's regulatory processes could be applied broadly in the workplace, at war, and in everyday life. The phrase "sociology of work," in contrast, is meant to describe efforts to observe and describe worker interactions as well as the study of informal organization.

The Rockefeller foundation invested heavily in both the sociology and the physiology of work. A review of accounting documents maintained by the foundation reveals that from 1930 to 1937 Harvard received $875,000 dollars in unrestricted funds for research in Industrial Hazards.[323] Additional documents show that supplemental grants ranging in size from $1,000 to $12,000 dollars were occasionally made for the procurement of instruments over the course of the same seven-year period. At Harvard, foundation funding for Industrial Hazards was primarily used for infrastructure development, such as financing the fatigue laboratory in the basement of the Business School, or capacity building, for instance, recruiting scientists from around the world that the University would not otherwise sponsor through formal faculty appointments. The RF also made significant contributions to established Yale's Institute of Human Relations.[324]

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[323] Rockefeller Archive Center, RFRG1.1, Box 342.

[324] J.G. Morawski, "Organizing Knowledge and Behavior at Yale's Institute of Human Relations," *Isis* 77, no. 2 (1986): 219-242; Arthur J. Viseltear, "Milton C. Winternitz and the Yale Institute of Human

Knowledge of the physiology of the normal laboring body could be put to generative use—it could be used to determine wages, to predict potential losses caused by worker injuries and turnover, or to determine how much work could be expected from a worker at extreme temperatures, altitudes, and other environments. Henderson's understanding of the scientific study of man is therefore best understood as a science of what is possible and what can be expected. For Henderson and the HFL, the emphasis was on elaborating the ways in which interactions (between workers and workers and the environment) mediate the limits of adaptability.

Unlike previous studies that have argued that the Rockefeller Foundation sought to use business methods to reform the scientific enterprise to improve efficiency, then, this study seeks to ground the foundation's work in a different rationality. The study of man as a complex organism served as the basis upon which scientific research was to be organized. The RF's system of patronage was focused on developing research capacity along distinct lines of scientific investigation. This chapter will therefore examine a series of research studies undertaken by social scientists and physiologists at the Harvard Fatigue Lab, which took man, as a complex organism, as the object of investigation.

The Strain of Social Contacts: The Factory Floor as Social Space

> Social contacts in industry, often close and constant, often unavoidable and formed without choice, are accompanied by emotional strain which may not only interfere with effective collaboration but lead to a marked decline in individual efficiency, and even to incapacity for work.[325]

Relations: A Brief Chapter in the History of Social Medicine," *The Yale Journal of Biology and Medicine* 57 (1984): 869-889

[325] The above quote was taken from a report made by the National Research Council's "Committee of Work in Industry." The committee consisted of Chairman L.J. Henderson, secretary George C. Homans, and members Elton Mayo, F.W. Willard, W.S. Hunter, G. Canby Robinson, and H.J. Ruttenberg. Future

With the emergence of modern welfare-states in the late nineteenth century—in countries like Germany, France, Britain, and some would argue the United States—came a new concern for the conditions of work in industry. This concern took the form of work-related legislative acts meant to protect workers from injury, illness, disability, and/or poverty in old age. In many of these countries, government leaders initiated elaborate research programs to study the economic cost and productivity of labor. Attempts were also made to tap into the maximum potential of human labor power. In Germany, for example, compulsory accident and sickness insurance laws passed in 1883 and 1884 created "sickness funds"—providing monetary compensation—for injured workers and established that employers were liable for the health and safety of their employees.[326] The First World War brought a new set of labor-related concerns: how do long hours and intensive manual labor impact human physiology and productivity? The British Government, for example, established the "Health of Munitions Workers Committee" in 1915 to study the effects of physiological fatigue on workers.[327] Following the war, the intense demands on war-related industries subsided. The reality of physiological fatigue—working to the state of physical exhaustion—became less common among laborers.

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references to this report will be abbreviated as CWI (Committee of Work in Industry). See, George C. Homans, *Fatigue of Workers Its Relation to Industrial Production* (New York: Reinhold Publishing, 1941).

[326] For a study of the impact of thermodynamic theories in shaping modern conceptions of work and human potential in Western Europe see, Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity,* (Berkeley: University of California Press, 1990).

[327] The Ministry of Munitions, Health of Munition Workers Committee of Great Britain published a series of reports on the problems affecting munitions workers during World War One. The reports covered issues relating to the employment of women, hours of work, and fatigue, see Health of Munitions Workers Committee, *Final Report: Industrial Health and Efficiency*, vol. 11, (London: Ministry of Munitions, 1918). After the war the committee was renamed the "Industrial Fatigue Research Board." These institutes were precursors the Harvard Fatigue laboratory which was established in 1927.

It was within this social and economic context that Elton Mayo and his colleagues began their studies on the "social conditions" of work. Mayo was an Australian trained psychologist best known for best known for his role in the Hawthorne Experiments and the development of the so-called Human relations movement.[328] Mayo's interest in the psychology of labor relations began in 1904 when he served as a volunteer teacher at the London based Working Men's College. It was here that he worked closely with English laborers and became familiar with the concerns and struggles of working class people.[329] Soon after this experience he enrolled in a doctoral program at the University of Adelaide to study a mix of philosophy and psychology under the tutelage of Professor William Mitchell. In 1911 he was appointed lecturer in logic, psychology and ethics at the University of Queensland. He spent the next eleven years at the University of Queensland, eventually becoming departmental chair. During this time he explored new psychotherapeutic methods on shell shocked men returning from the war and labor activists.[330] His observations during World War One yielded a small book titled *Democracy and Freedom* (1919) in which he fiercely critiques the failures and limitations of democratic government. He argued that "Democracy, as we at present know it, is based upon a misunderstanding of the facts of human nature and social organization."[331] He claimed that

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[328]Mayo is perhaps best remembered for his book Mayo, *The Human Problems of an Industrial Civilization* (New York: Macmillan, 1933). For a biographical study of Elton Mayo and his work see, R. C. S. Trahair, *The Humanist Temper: The Life and Work of Elton Mayo*, (New Brunswick, NJ: Rutgers University Press, 1984).

[329]J. H. Smith, "The Enduring Legacy of Elton Mayo," *Human Relations* 51 (1998):229.

[330] Helen Bourke, "Industrial Unrest as Social Pathology: The Australian Writings of Elton Mayo," *Australian Historical Review* 20, no. 79 (1982): 217-233.

[331] Elton Mayo, *Democracy and Freedom: An Essay in Social Logic*, (Melbourne: MacMillan, 1919), 13.

without a better understanding of social and political philosophy, one could not be certain that "democracy moves in the direction of human freedom and personal autonomy."[332]

Three years after the publication of *Democracy and Freedom*, Mayo emigrated to the United States to conduct research at the University of Pennsylvania. In 1925 Mayo was recruited from the University of Pennsylvania to Harvard by Donham (Dean of HBS) and Henderson. Both men believed that Mayo's work on human relations in industry was of "tremendous importance."[333] Despite their enthusiasm for his work, it was challenging to secure funding to support Mayo's research and secure him a more permanent place at Harvard.[334]

Henderson and Mayo both shared a mutual interest in sociological analysis and a politically conservative bent. Most importantly, the two men shared an interest in applying the methodology of the medical sciences to sharpen the professional skills of social scientists and encourage social stability.[335] Nowhere is their interest in the application of social theory and medical sciences more apparent than in the Hawthorne Experiments which took place from 1924 to 1933 at the Hawthorne Works of the Western Electric Company.[336] Located just outside of

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[332]Ibid.

[333] RAC, Harvard University Industrial Relations, f 572, SIII-6, 1924-1928.

[334] Jeffrey L. Cruikshank, *A Delicate Experiment: The Harvard Business School, 1908-1945*, (Boston: Harvard Business School Press, 1987), 163.

[335] Stephen J. Cross and William R. Albury, "Walter B. Cannon, L. J. Henderson, and the Organic Analogy," *Osiris* 3, 2nd Series (1987): 182; Richard Gillespie, *Manufacturing Knowledge: A History of the Hawthorne Experiments* (Cambridge: Cambridge University Press, 1991), 119; J. H. Smith, *The Significance of Elton Mayo, Forward to Mayo, the Social Problems of an Industrial Civilization*, (London: Routledge and Kegan Paul, 1975), 42.

[336] Although Mayo and his colleagues came in as consultants, they were ultimately responsible for publishing and distributing their findings to a broader audience. For a fascinating historical study of the experiments, their findings, and their reception by the sociological and management communities see Gillespie, *Manufacturing Knowledge*.

Chicago, the Western Electric's Hawthorne plant was an ideal site for Mayo's research. For the first few years of his involvement, Mayo's role primarily consisted of interpreting the data and suggesting potential avenues for future studies. It wasn't until 1930 that he was permitted to play a more active role in designing an actual study. From that point on, The Hawthorne studies represent an important shift from theories of scientific management toward an applied theory of human relations. According to Taylorism and traditional efficiency studies, workers were primarily motivated by economic incentives. The Hawthorne studies sought to show that social relationships and physiology—not economic interests—determined worker behavior and productivity.

Nearly a century after the fact, scholars continue to reinterpret the data collected during the Hawthorne studies, and sociologists continue to apply some of the theoretical insights gained by the studies.[337] The aim here instead is to historicize the transformation of the notion of the workplace as a social space in which individual workers forged relationships and participated in informal organizations. The Hawthorne studies were not only unique in matters of scale or in the overall argument developed by the researchers: they are historically relevant because they mark the moment that social theorists began to see the factory floor as a social environment. The workplace is an environment that is governed and ordered because of, not in spite, of social relationships. For these researchers, understanding the social environment of the workplace would be a crucial step in improving worker output.

[337] As historian of science Richard Gillespie notes, very little historical attention has been given to the Hawthorne studies. Gillespie's book remains the only book-length work on the history of the studies. His book focuses primarily on the ways in which researchers made use of scientific rhetoric in an effort to legitimate their findings. He places the Hawthorne studies within a broader moment in the history of the social sciences, in a period of popular and professional transformation. Gillespie, *Manufacturing Knowledge.*

The structured interview is perhaps the most important artifact to come out of the Hawthorne studies. Although Hawthorne staff had attempted to conduct their own interview program prior to Mayo's involvement, their efforts were unstructured and unsystematic. In contrast, Mayo placed the 90-minute interview at the center of his studies. Many of Mayo's future publications relating to the studies done at the plant draw on the several thousands of interviews conducted by his team between 1930 and 1932. The structured interview had, and continues to have, a far-reaching practical impact on the conduct of qualitative sociological research.[338] The remainder of this section discusses the development of the structured interview, as it evolved during the Hawthorne studies.

The interview was an empirical method for collecting social information. It gave the researcher partial entry into the life of the worker. It allowed the researcher to deal with the most difficult tasks facing social science—"the problems bearing on individuals in their actual situations."[339] When analyzed together, the individual interviews could provide a synthetic overview of the social conditions of a given work place. At the end of their studies, the researchers drew four conclusions in relationship to the use of the interview method: 1) The interview method is indispensible in industrial and medical investigations; 2) it can yield

[338] I differentiate the practical from the well-demonstrated rhetorical and ideological impact the studies had on the discipline of sociology (well demonstrated in Gillespie's study). The practical impact refers to the influence of the interview on the practice of sociological research. Sociologists continue to use the 90-minute interview as the gold standard of qualitative research. Although different variations have since been developed, Mayo's influence is undeniable. It is also possible that Mayo's interviewing method, has had an impact on other fields. For example in the field of Human Relations (HR), one might speculate that the "job interview" is a shorter, more condensed version of Mayo's interview method. Robert K. Merton's work on the focused interview also shares some key characteristics with Mayo's work. See Merton, *The Focused Interview; a manual* (New York: Columbia University, 1952). The interview can also be differentiated from other practices which Mayo introduced which have since been discontinued: for example taking pulse measurements of workers to determine their physical and psychological fitness for work.

[339] Homans, *Fatigue of Workers,* 10.

information of theoretical importance; 3) its utility has been empirically proven; and 4) researchers can be trained to use the method. In short, the method is scientific in its reproducibility.

The Hawthorne Works provided the perfect setting in which to test, revise, and optimize the interviewing technique. By 1929 the company had more than 40,000 employees from different ethnic and national backgrounds, and a mix of skilled and unskilled workers. Prior to Mayo's involvement with the interviewing program, employees from the personnel department at Hawthorne began to interview the workers as part of an attempt to gather information about worker's attitudes towards their workplace conditions and employer. Their approach appears to have been haphazard and unsystematic. Richard Gillespie notes that the workers responded with mixed feelings to the interviewing program.[340] They were suspicious of the interviewer's intentions, and questioned the sincerity of management's commitment to taking their grievances seriously. This did not limit managers' enthusiasm for the program: by the time the first round of interviews was completed by 1929, Gillespie notes, the interviewers had conducted and analyzed 10,300 interviews.[341] The analysis of the results was equally unsystematic. The results showed that workers were unhappy with their supervisors and felt they were not being taken seriously. Aside from this consistent finding, the conclusions were mixed, and for the most part not very useful.

In 1930, when Mayo joined the interviewing team, he had a new approach in mind. In a privately distributed document detailing the interview method, Mayo cites work of Janet, Freud,

[340] Gillespie, *Manufacturing*, p. 130.

[341] Gillespie, *Manufacturing*, 131.

Piaget, Pareto, and Henderson as providing the theoretical foundation for his interview method.[342] In addition, his interviewing technique was informed by his own experiences—and those of his prominent colleagues—in anthropology, medicine, and clinical psychology.[343] As a first step, Mayo hired new interviewing staff. By 1930, half of the interviewers from 1929 had been replaced, only two of which were permanent staff. Mayo directed his interviewers to conduct their interviews in a conversational style, as opposed to a survey style. As the method improved, so did the length of the interview, eventually reaching a standard of ninety minutes. In his book *The Human Problems of an Industrial Civilization* (1933), Mayo reports that within a month of conducting the interviews, the chief interest of the investigation had become "the proper method of conducting an interview."[344] Mayo soon realized that if executed properly, the interview could be used to extract almost any kind of personal information from an employee.

A successful interview required the worker's confidence—the interviewer had to establish rapport with his subject. Developing the proper techniques with which to gain the confidence of a worker became the central methodological challenge. To do this, Mayo suggested that the interviewer always follow the worker's lead. This began at the moment the interviewer was introduced to the employee: the interviewer was directed to 'catch-on' in a conversational way, at any starting point mentioned by the employee.[345] The main goal was to encourage the employee to talk, by following his lead and demonstrating a genuine interest in

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[342] Rockefeller Archive Center, Box 342, Folder 4072.

[343] Gillespie gives an interesting discussion of the influence of Swiss Psychologist, Jean Piaget on Mayo's conception of the interview as tool for increasing self-awareness in research subjects in Gillespie, *Manufacturing*, 134.

[344] Elton Mayo, *The Human Problems*, 86.

[345] Ibid., 89.

what he had to say. The interviewer should take notes to enable him to keep track of the employee's narrative. The notes could then be used to ask clarifying, not leading questions. At all points of the interview, the interviewer was to give his full attention to the person being interviewed. At no point should the interviewer argue with, or give advice to the interviewee. He was instructed to never change the subject or to ask questions about topics the employee has shown little interest in. The emphasis was on listening, not talking. At all times, the goal of the interview was to keep the employee engaged in conversation and at ease. Last but not least, the interviewer must ensure the interviewee that the information shared during the interview would be kept confidential.[346]

Underlying many of the rules and techniques of Mayo's interview method are assumptions about the personal life and emotional needs of working-class Americans.[347] In Mayo's reports, the workers at the Hawthorne are represented as starved for attention. Attention therefore becomes the central gateway for establishing their trust and confidence. If the interviewer even suggests a slight lack of interest or skepticism, trust is lost, and the interview is rendered useless. Similarly, in claiming that the interview encounter gave the employee a rare opportunity to express himself, Mayo was suggesting that the average working-class American lived a life of social isolation.

If Mayo expected these more freeform, longer interviews to lend themselves to easier analysis, he was mistaken. When the content of the interviews—the individual attitudes and

[346] This last rule was added in the 1940s.

[347] It is unclear as to whether or not these are assumptions or empirically based conclusions. It would be interesting to do a more complete study of the interview transcripts to try piece together a picture of the social and emotional life of workers in the 1930s. Since I have not had the opportunity to do so, I will treat Mayo's conclusions with some skepticism.

personalities of the employees—were studied, the workers' responses were categorized as favorable or unfavorable toward the company. They found that "comments on material conditions of work had a higher validity than comments about persons."[348] By higher validity they were referring to their ability to identify confirming evidence of the problem. This included complaints about workplace conditions such as smoke, ventilation, or insufficient space. Complaints about supervision were disregarded; they were interpreted as having meaning only within the context of the individual's life. In other words, those problems that were considered to be beyond the immediate control of the worker—occupational hazards and workplace structure—were categorized as material. Issues deemed to be within the employee's control were categorically dismissed. Mayo and his colleagues concluded that the interview program had demonstrated that problems in industry—mainly labor dissatisfaction and cases of social unrest in the workplace--were more complex than poor material working conditions or bad supervising. The real problems in industry were caused by "something more intimately human, more remote."[349] Problems in industry were reconstituted as simply "human situations." Each case had to be considered individually, and many had no solution.

This mode of analyzing interview data reveals some basic assumptions about how Mayo and his colleagues conceptualized the relationship between the individual and the group. Those experiences that motivate us to do certain things, that we talk about and care about, have a more universal meaning. These motivations are formed on a group level; they are not individually determined. And yet, the manifestation of these universally structured desires and motivations can only be understood on an individual level. For this reason, different events—although

[348] Mayo, *The Human Problems*, 96.

[349] Mayo, *The Human Problems*, 98.

motivated by the same social forces—can take on a wide range of different meanings. The individual is often incapable of truly understanding why he has taken certain actions, or why he has chosen to discuss certain topics with the interviewer. Motivation is not immediately accessible to the individual.[350] An individual's interpretation or attitude toward a given situation, however, is open to revision.

It is interesting to consider how these assumptions about human nature have shaped the way in which we analyze interview data today. At the time Mayo and his colleagues developed the structured interview, it proved to be a powerful social management technique. One might even call the structured interview a "technology of the self," in the sense that it focuses all eyes, ears, and solutions on the individual. Technologies of the self refer to the methods and means by which the "self" is constituted and cultivated as a subject. This highly adaptive and flexible technique is said to allow the trained interviewer to help the interviewee become empowered by becoming responsible for his own unhappiness. Although the data from the Hawthorne experiments have been discussed, disputed, criticized, and celebrated, the methodological breakthrough that produced the data has not been carefully examined. Mayo himself stated that the interviewing technique should be used by industry "to exploit or anticipate emotional situations." By the time he finished his study; emotional situations were considered to be one of the most widespread threats to the social equilibrium of the workplace. The interview was its only antidote.

[350] This conclusion is drawn from the basic assumptions evident in Mayo's interview method. Although this method sets up a dichotomy between the accessible and inaccessible, it is not completely based on Freud's theory of the unconscious. Instead, Mayo's argument turns on a fundamental difference in unit of analysis. The individual is scarcely aware of those things which only emerge within a larger "social situation." He is always focused on making meaning of his own life and experience. And yet the social allows the individual to exist. Based on this assumption Mayo equates human situations to social situations. The two are one of the same.

The Hawthorne studies made it clear that social interactions are just as important as the physical conditions of a workplace. It also showed that the factors motivating workers are highly complex and in many cases directly related to the social order within a given context. This social order is understood as part and parcel of the social system. It is within the social system that the individual workers operate and impact one another; collectively creating the social environment. The Hawthorne studies showed that a workplace could be analyzed as a social system of mutually dependent variables. It was perhaps the most popular and widely circulated application of the theory of social systems. Henderson and Mayo both believed that the Hawthorne studies had succeeded in establishing that the workplace was indeed a social system and that social interactions were just as crucial for understanding the conditions of work. While other HFL studies looked specifically at physiological systems, the Hawthorne studies were primarily interested in the functions of the social system on the factory floor.

Work in Hot Climates

The HFL studies in hot climates were some of the most interesting and notorious because of the debilitating impact excessive heat can have on the laboring body. The studies were undertaken primarily to solve the problem of heat stroke; which can result in death and was often the cause of high turn-over rates in industrial worksites where workers are exposed to prolonged periods of intense heat. In the 1930s, there were good clinical descriptions of the effects of high external temperatures on the body, but there was nearly no quantitative chemical data on the physiological effects of working in hot climates.[351] In addition, the heat studies demonstrate a range of industrial priorities and new developments both within and beyond the United States.

[351] David B. Dill, "A Resume of Some Physiological Reactions to High External Temperature," 209 (1933):442.

The need to understand how different bodies respond to high temperatures was directly linked to the growing presence of American industrial interests in tropical and semi-tropical climates. The HFL studies on work in hot climate sought to "consider some of the means by which the body reacts in adjusting itself to high external temperatures."[352] Just as in the Hawthorne studies, the HFL was interested in understanding the mechanism by which individuals adjust or fail to adjust to a given environment. Only this time they were interested in the individual as a physiological system.

The heat studies were used to establish that the body worked at its best when in a state of equilibrium; a physiological "steady state". The HFL found that if workers were given access to water containing added salt—to replace the loss of electrolytes during work—and air conditioned living quarters—they could maintain a physiological steady state. The HFL researchers concluded that intense heat in the workplace did not necessarily cause physical fatigue. Instead, they argued, physiochemical "imbalance" or boredom was the true cause of fatigue. In other words, these studies were used to justify harsh working conditions and resolve existing problems with minimal changes to the actual labor processes. Whereas the Hawthorne studies were primarily concerned with the social conditions of work, the heat studies represent a concern with the physical conditions of work in industry. In both instances, at the Hawthorne plant and construction of the Boulder Dam, the HFL sought to move beyond the laboratory and study the organism's adaptation to changes in the environment under "natural conditions." This section discusses how this initial research took place in Boulder Dam (1932), a publicly funded large scale infrastructure project.

Like the Hawthorne studies, HFL's heat studies applied the new field studies techniques to the study of healthy individuals experiencing a broad range of natural stresses. The heat

[352] Ibid.

studies run parallel with some of the largest infrastructure development projects undertaken by the U.S. government during the middle decades of the twentieth century. They demonstrate how developments in applied physiology were part of a larger project aimed at building the nation. Studies on heat exhaustion had a very direct and practical significance in the modern industrial workplace. In addition to resolving some of the immediate practical problems confronted by workers in hot climates, the field studies sought to understand the nature of acclimatization. The researchers relied on the participation of native inhabitants—both people and animals.

The building of Boulder Dam, formally renamed Hoover Dam in 1947, began in 1931. The dam was built to provide water to the region and a much needed source of hydroelectric power. At 730 ft. high, the Boulder dam was, at the time it was built, the highest in the world and subsequently posed great danger to the men engaged in building this massive concrete structure. This unprecedented public work was built cooperatively by government and business.[353] In the first year of the project alone fifteen workers died from the heat. The dry heat and crude living conditions in Black Canyon, straddling the border between Arizona and Nevada made the backbreaking work intolerable. The deaths and associated injuries gave rise to worker unrest and public outcry regarding working conditions at the construction site.[354] When Commissioner of

[353] The six construction firms that built the dam were known collectively as "Six Companies, Inc.". The group included: Henry J. Kaiser Co. partnered with Bechtel Corporation, J.F. Shea, Pacific Bridge Company, Utah Construction Company, MacDonald and Kahn, and Morrison-Knudsen.

[354] "200 Will Die in Building of Boulder Dam: Five Workers Already Give Lives—Labor Conditions May Bring Quis," *New Leader with Which Is Combined the American Appeal* 13, no. 2 (1931): 2; "California Unions Urge U.S. Take Hoover Dam From Private Company," *New Leader with Which Is Combined the American Appeal* 13, no. 8 (1931):2; "A Symbol of Hooverism: Strikers Demand Decent Food and Drinking Water: Men Die Like Flies at Construction Site," 13, no. 8 (1931): 1; Todd Laurence, "Hoover Dam Called Nest of Anti-Union Exploiters," *New Leader with Which Is Combined the American Appeal* 15, no. 8 (1933): 10.

Reclamation Service, Dr. Elwood Mead, addressed an audience of engineers at the Massachusetts Institute of Technology he described the climate as follows:

> The summer wind which sweeps over the gorge from the desert feels like a blast from a furnace. At the rim of the gorge, where much of the work must be done, there is neither soil, grass nor trees. The sun beats down on a broken surface of lava rocks. At midday they cannot be touched with the naked hand. It is bad enough as a place for men at work. It is no place for a boarding house or sleeping porch.[355]

The conditions were widely recognized as dangerous, but very little effort was made to protect workers beyond providing them with housing near the work site. As the number of deaths began to accumulate and news coverage circulated it became clear that something needed to be done.

In 1932, after securing the cooperation of the government and the construction companies, the Harvard Fatigue Lab sent a team of nine investigators to Boulder City, Nevada to study the effects of dry heat on laboring bodies and to find the cause and solution to the "large number of prostrations, heat cramps, and breakdowns of other types."[356] This was the HFL's first dry heat field study and their first government contract.

Once on site, the HFL researchers established a temporary laboratory in the basement of the Municipal Building in Boulder City, Nevada, located approximately seven miles from the dam construction site.[357] The lab was set up to conduct a range of laboratory studies—including urine analysis, blood analysis, changes in respiratory response, and heart rate monitoring—on

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[355] Dr. Elwood Mead quoted in Judson King, "Open Shop at Boulder Dam," *The New Republic* 67, no. 864 (1932): 147. For an extensive history of the construction of the Hoover Dam, including the political and technical challenges see, Joseph E. Stevens, *Hoover Dam: An American Adventure*, (Norman, OK: University of Oklahoma Press, 1990).

[356] Homans, *Fatigue of Workers*, 24. The nine HFL affiliates sent to Boulder City, Nevada included: David B. Dill, John H. Talbott, Jost Michelsen, William Consolazio, Frank Consolazio, A.V. Bock, H.T. Edwards, Hadin Jones, and S.A. Oberg.

[357] Dill, "A Resume," 442.

members of the lab and the workmen. They found that in dry heat, the body is capable of maintaining a comfortable temperature and relatively low heart rate.[358] However, comfortable internal temperature and low heart rate is accomplished by the evaporation of large quantities of water, "with inevitable loss of considerable salt in the sweat produced."[359] In most cases, the observed breakdowns were caused by the failure to maintain a proper salt balance. They concluded that the failure to maintain the salt balance was related to a "poor instinctive mechanism of the human body."[360] Rather than craving salt, the workmen and researchers simply continued to drink regular water. Without a mechanism by which these salts were replaced, the men quickly became deficient in salt which lead to "the breakdown state" and heat cramps. "Since instinct was not operating," the researchers noted, "conscious planning had to take its place." With these findings in hand, the HFL recommended that the workmen be given plenty of salt containing water throughout the day.

The HFL also conducted studies bearing directly on the proper living conditions for inhabitants of labor camps set up by corporations. The labor camp that had been established for the laborers was erected in the river canyon. The shade temperature in the river canyon was frequently above 100°F past midnight. Sleeping under these conditions was nearly impossible. HFL researchers noted that the men were "unable to restore their bodies to a normal state by the end of the 24-hour period."[361] Finally, upon the recommendation of the HFL, new dormitories were established 1,500 feet above Boulder Dam where the temperature was approximately 15°F

[358] Homans, *Fatigue of Workers*, 25.

[359] Ibid.

[360] Ibid.

[361] Ibid., 26.

lower than down the canyon. The newly built dorms were also equipped with air-conditioning equipment. Having achieved their goal of finding the cause and cure of heat related injuries, the HFL researchers concluded that the "average workman had become acclimatized and was able to carry on and enjoy life."[362]

These studies helped to bolster the HFL's evolving definition of fatigue. "Probably the best general definition [of fatigue], which does not commit us to any explanation of its nature," Mayo wrote, "is that it is a reduced capacity for doing work."[363] Fatigue, they argued, could not be defined as a single entity. This is where Henderson's conception of system becomes crucial. Henderson argued that the living organism is best conceived as a number of variables in a state of mutual dependence. In certain situations—for example in the case of the laborers discussed above—there is a "defect of external relation" that gives rise to "an organic unbalance in the individual "worker.""[364] The observed loss of sodium chloride due to excessive perspiration is understood as an imbalance between the worker and his physical environment resulting in a reduced capacity to do work. The minor interventions proposed by the HFL—salt water and cooler living quarters—were designed to enable the worker's body to return to a state of physiological equilibrium. In both the Hawthorne studies and the heat study at Boulder City, minor interventions were made to help the individual better adapt his/her environment.

Conclusion

It was within the context of the work place that the link between the physiological and the social gained practical significance and meaning. The field studies undertaken by the

[362] Ibid.

[363] Mayo, *Human Problems*, 9.

[364] Mayo, *Human Problems*, 22.

fatigue lab are each directly connected to distinct infrastructure projects undertaken in the 1930s and 40s. These projects were part of an effort to facilitate the transport of goods and people, trade, and harness new sources of energy.

An interactional approach to systems, in terms of work studies, differs from the case of medical practice in that we are presumably dealing with a healthy individual in the context of a public setting, the workplace. It is similar to the analysis of systems thinking in the clinical encounter because here again, in the context of work, we see attention to the mutual dependence of variables that make up the system itself. The context in which these studies take place are, however, much broader and of interest to a larger audience.

CONCLUSION

On February 10, 1942, Lawrence Joseph Henderson checked himself into Massachusetts General Hospital for surgery. He had been suffering from occasional bouts of pain and hemorrhage due to what he believed was an ulcer. Eventually he discovered that what he thought was an ulcer was in fact cancer. In the weeks prior to checking in for surgery, Henderson had been working hard on a new book based on his Sociology 23 lecture notes. The book was to be published as a series of case studies spanning topics as diverse as the Hawthorne Studies and social revolution. His work was interrupted by a visit to the hospital from which he never returned. The cause of death was recorded as carcinoma of the bladder and pulmonary embolus.[365]

Henderson's life ended just as the United States was undergoing a revolution of its own. The timing of Henderson's life and professional trajectory allows us to ask new questions about the relationship between the social sciences and the life sciences prior to disciplinary crystallization that occurred in the post-WWII era.

This dissertation has sought to capture the elusive moment when border crossings between the life and the social sciences were not only possible, but desirable. As I have attempted to show here, Henderson was not an outlier in any sense of the word. The kind of border crossing he was engaged in was not altogether rare. While it wasn't exactly common, Henderson was certainly not the only person moving in and out of different disciplinary worlds. What is historically interesting about Henderson is how his life provides the ability to see border crossings in more than one domain—the social sciences, social medicine, and industry—at the same time in a single person's biography. This dissertation has therefore used Henderson's

[365] Commonwealth of Massachusetts, Count of Middlesex, City of Cambridge, Death Certificate, Record No. 313.

professional trajectory as a comparative frame within these three domains to gain a better understanding of the relationship between the social sciences and the life sciences in the first half of the twentieth century. In the years following Henderson's death, this same kind of border crossing became not only more rare, but also far more difficult. This dissertation argued that, even though it appears that there is and has always been an opposition between the biological and the social, this opposition develops subsequent to Henderson's life. By tracing the continuous points of contact between the social and biological sciences in the first half of the twentieth century, this dissertation sought to explain how work like Henderson's could seem natural.

This is of course part of a much larger story of disciplinary politics and dynamics in the modern American university. The preceding chapters have illustrated one part of this story in detail by tracing Henderson's boundary crossing by following his development from a laboratory scientist to a social theorist towards the end of his life and career. Chapter One, was largely a biographical chapter devoted to giving the reader a sense of who Henderson was, the factors in his life that shaped his views, and the context of his thought and work. This chapter showed that Henderson's early border crossing from physics to chemistry in his study of physical chemistry was against the backdrop of rapid new developments in the physical sciences at the turn of the century. These developments made it possible for Henderson and his contemporaries to ask new questions about the application of physical sciences in the life sciences. The main goal of this chapter was to show how Henderson's training in physical chemistry, medicine, and physiology allowed him to bring a robust tool kit to the study of biology. It also showed that his privileged institutional location at Harvard and greater Boston gave him access to some of the leading figures in both the natural and the social sciences. In chapter two I looked more closely at

Henderson's first two published books, *The Fitness of the Environment* (1913) and *The Order of Nature* (1917). In this chapter I argued that in these first two books Henderson articulated a logic of systems that permeated all of his work. The goal of this chapter was to draw out what Henderson and his contemporaries meant by "system" and the uniqueness of a systems approach to the study of phenomenon. Henderson believed that a systems approach could be seamlessly used to study both physical and social phenomenon. This idea is then explored further in Chapter three which looked at Henderson's essays on the doctor patient relationship as a social system. This chapter looked specifically at how Henderson further developed and articulated his systems approach within the context of medical practice. The goal of this chapter was to explore Henderson's border crossings into a domain in which he had very little fist hand experience in, social medicine. Here we see Henderson once again promoting a "systems" approach to medicine with the goal of bridging laboratory practice and clinical practice. Systems could be used to understand these boundaries and ultimately bridge them. In the fourth and final chapter I looked at the application of this systems approach in the context of industrial practice and labor studies. In this chapter we see how Henderson brings together his interpretation of Pareto's work and his previous work on physical systems to study social equilibrium and the conditions necessary to create a stable workplace. It is here that we see Henderson engaged in articulating a theory of social control and authority in his writings on Pareto as well as through his correspondence with other actors directly involved in industrial management. In this chapter I argued that the porousness of boundaries between disciplines can also be seen at the institutional level in the boundary crossing between the university and the industrial workplace. What we see is that as Henderson got older, most of his work began to focus on social theory and the study of "social" systems. He became more and more interested understanding social equilibrium and

most importantly social order. Henderson was indeed quite conservative when it came to questions of social stability and order. He favored a vision of the world where he and others like him were at the center, upholding the status quo. He believed that “the masses” did not have the capacity to rule themselves or others. Indeed, he despised Roosevelt and his progressive political agenda. Henderson, like Pareto, believed that people were dominated by their sentiments and were therefore rarely engaged in logical decision making. Although his political views can be easily criticized, it is nonetheless important to consider the context in which Henderson developed these views. As a son of a merchant, he had seen the devastating economic consequences that could be brought on by social instability. Perhaps even more importantly, he had lived through World War One and all of its destruction. Towards the end of his life he became increasingly concerned about the likelihood that the US would enter into yet another World War. In other words, Henderson came of age during a period of great change and political discord. His preference for political and social stability was at least in part a consequence of this. That said, Henderson was also part of a certain social class whose life was changing and becoming much smaller. He, like many of his contemporaries, did not want to let it go in exchange for a much more diverse, progressive (at least in theory), and democratic world.

Together these chapters painted a picture of boundaries being crossed and made. This type of intellectual activity would today be classified as interdisciplinary. Interdisciplinarity in American universities in the first half of the twentieth century served two purposes. First, it was a response to the perceived complexity of the problems facing American society and the world. An emphasis on systems and mutual dependence mirrored the belief that indeed the world was interconnected, and interdisciplinarity offered an increasingly appealing approach to solving problems. Second, interdisciplinary research centers became an effective strategy for raising

funds from foundations and for organizing people and money around a common set of themes. The theme could be something large and ambitious that could not realistically be covered by a single discipline alone. This tension between disciplines, and the enormity of problems facing society, endured throughout the twentieth century and indeed into the present day.

The kind of border crossing that Henderson and his contemporaries engaged in came at a time of major social transformation and instability. Henderson and his contemporaries were not just ambitious; they were entrepreneurial in their approach to knowledge production and collaboration. They were opportunistic and found ways to make the traditional university structure work for them. Today we see this type of activity in the restructuring of the academic labor market. It is no longer just tenure or bust; people are making careers in temporary and contract-based posts. Could this be the sign of a restructuring of the university?

A future study might compare interdisciplinarity in the pre-WWII and post-WWII American university. One might examine, for example, the different functions of interdisciplinary projects in these two eras. The major limitation of this work is that it focuses on a single historical actor. Like all biography, the personal narrative is both compelling and limiting in historical analysis. Additional studies of other prominent figures who engaged in similar kinds of border crossing might help to broaden the context of these arguments. Were there, in fact, others like Henderson, but perhaps less prominent? Is this kind of border crossing something that could only have been done in the context of Harvard, or other elite schools? Future studies might focus their attention on other peer institutions—such as John's Hopkins, Yale, Columbia University, or Stanford—as well as different kinds of institutions—state schools, land-grant schools, research institutions not affiliated with universities, and, in the postwar period, federally funded research contract centers..

The evidence presented in this dissertation examined the dynamics of interdisciplinarity in the first half of the twentieth century. On a more granular level, it showed how one individual, Lawrence J. Henderson, moved from physical chemistry to social theory over the course of his career. Along the way I demonstrated how Henderson used the concept of systems to articulate a transdisciplinary vision of how one might study interactions between seemingly unrelated phenomena. By looking at Henderson's biography in chapter one we learn that Henderson's unique training and interests allowed him to develop a robust skill set necessary for moving in and out of these different domains. This somewhat narrow conclusion shows that Henderson was able to do all of this because of the unique set of circumstances that marked the historical moment in which he developed as a student, scientist, and later professor. As stated before, this was a period rapid growth at Harvard University and development in the social and natural sciences. This early period of development made it easier for Henderson to cross borders and influence, even if just on a local level, the establishment of the social sciences—mainly human relations and sociology—as well as physical chemistry at the medical school. Henderson's efforts to form bridges among distinct domains described in the preceding chapters can be regarded as part of a larger moment in which crossing boundaries and making boundaries was encouraged and necessary for the development of the social sciences and the natural sciences in the decades following WWII.

BIBLIOGRAPHY

Unpublished Primary Sources

American Philosophical Society

Raymond Pearl Papers, American Philosophical Society.

Countway Library of Medicine

Harvard Fatigue Laboratory Records, 1916-1952 (inclusive, 1941-1947) bulk. Harvard Medical Library, Francis A. Countway Library of Medicine, Boston, Mass.

Harvard Business School Archives

Chester I. Barnard Papers, Harvard Business School Archives, Baker Library, Harvard Business School.

Elton Mayo Papers, Harvard Business School Archives, Baker Library, Harvard Business School.

Lawrence Joseph Henderson Papers, Harvard Business School Archives, Baker Library, Harvard Business School.

Harvard College Library

Lawrence J. Henderson, "Sociology 23: Introductory Lectures" 1938, Harvard College Library.

Harvard University Archives

Alumni Files and Student Folders, Harvard University Archives.

Bowdoin Prize, Submitted November 1, 1897, "The Hypothesis of Electrolytic Dissociation", 89.165.620, Harvard University Archives.

Charles Sidney Burwell papers, 1924-1967 (inclusive). H MS C65. Harvard Medical Library, Francis A. Countway Library of Medicine, Boston, Mass.

Class Notes for History of Science I: 1941–42, 8941.341.1.95, Harvard University Archives.

Endowment Funds of Harvard University, Harvard University Archives.

Harvard Alumni Bulletin, Harvard University Archives.

Lawrence Joseph Henderson, Harvard University Archives.

Notes on History of Science I, 1913–1914, Professor Lawrence J. Henderson, HUC8913.3.39.1, Harvard University Archives.

Richard Clarke Cabot Papers, Harvard University Archives.

Massachusetts Vital Records

Massachusetts Vital Records, City of Lynn.

Rockefeller Archive Center

Harvard University Industrial Relations, 1924-1928, Laura Spellman Rockefeller Memorial Fund, SIII-6, B53, Rockefeller Archive Center.

Industrial Hazards Collection, Rockefeller Foundation, RG1.1.

Stanford University Archives

Bernard De Voto Papers, Stanford University Archives.

Published Primary Sources

Barnard, Chester Irving. *The Functions of the Executive*. Cambridge, MA: Harvard University Press, 1938.

Barnard, Chester Irving. "Skill, Knowledge, and Judgment." Commencement Address, Massachusetts Institute of Technology. June 9, 1950.

Berkson, Joseph. "Review: The Mechanics of Teleology." *The Quarterly Review of Biology* 4, no. 3 (1929): 415-419.

Bock, Arlie V. "Lawrence Joseph Henderson, 1878–1942." *Transactions of the Association of American Physicians* 57, (1942): 17–19.

Brinton, Crane. "Lawrence Joseph Henderson, 1878-1942." In *The Saturday Club: A Century Completed, 1920-1956*, edited by Edward W. Forbes and John H. Finley, 207-214. Boston: Houghton Mifflin Co., 1958.

Brown, Harold Chapman. "The Order of Nature by Lawrence J. Henderson." *The Journal of Philosophy, Psychology, and Scientific Methods* 14, no. 20 (1917): 558.

Brown, J. Douglas. "The Development of the Old-Age Insurance Provisions of the Social Security Act." *Law and Contemporary Problems* 186 (1936): 186-198.

Cannon, Walter B. *The Wisdom of the Body*. New York, W.W. Norton & Company, 1939.

Cannon, Walter B. "Lawrence Joseph Henderson, 1878-1942." *Biographical Memoirs of the National Academy of Sciences* 23 (1943): 31-58.

Cannon, Walter B. "The Relations of the Medical School." *Boston Medical and Surgical Journal* 161, no. 22 (1909): 790–791.

Cannon, Ida M. “Teaching Medical Students the Social Implications of Sickness.” *New England Journal of Medicine* 211, no. 5 (1934): 216.

Creighton, J.E. “The Order of Nature: An Essay by Lawrence J. Henderson.” *The Philosophical Review* 27, no. 6 (1918): 659-665.

Dearborn, Walter F. “Education in Medicine.” *Harvard Bulletin,* 12, no. 7 (1909).

Dill, David B. “A Resume of Some Physiological Reactions to High External Temperature.” 209 (1933): 442-444.

Dill, David B. “L.J. Henderson, His Transition From Physical Chemist to Physiologist: His Qualities as a Man.” *The Physiologist* 20, no. 2 (1977): 1.

Downs, A. W. “Blood, A Study in General Physiology.” *The Canadian Medical Association Journal* (1928): 755–756.

Dupree, A. Hunter, and Talcott Parsons. “The Relations between Biological and Socio-Cultural Theory.” *Bulletin of the American Academy of Arts and Sciences* 29, no. 8 (1976): 14-18.

Eliasberg, W. "The Social Implications of Dysphasia." *The Journal of Nervous and Mental Disease* 105, no. 5 (1947): 465-476.

Falk, I. S. “An Introduction to National Problems in Medical Care.” *Law and Contemporary Problems* 6, no. 4 (1939): 497-506.

Field, Mark G. “Some Problems of Soviet Medical Practice: A Sociological Approach.” *The New England Journal of Medicine* 248, no. 22 (1953): 919-926.

Foster, G. B. “The Influence of Environment.” *The American Journal of Theology* 17, no. 3 (1913): 457.

Haldane, J.S. “Claude Bernard’s Conception of the Internal Environment,” *Science* 69, no. 1791 (1929): 453-454.

Harrow, Benjamin. “Man Lives in a World Made to Order: A Physical Chemist Analyzes Our Friendly Environment.” *New York Times* (1925): BR16.

Health of Munitions Workers Committee. *Final Report: Industrial Health and Efficiency,* vol. 11. London: Ministry of Munitions, 1918.

Henderson, Lawrence J. “Mechanism, from the Standpoint of Physical Science.” *The Philosophical Review* 27, no. 6 (1918): 571-576.

Henderson, Lawrence J. “Physician and Patient as a Social System.” *New England Journal of Medicine* 212 (1935): 819-23.

Henderson, Lawrence J. “Review: A Philosophical Interpretation of Nature.” *The Quarterly Review of Biology* 1 no. 2 (1926): 289-294.

Henderson, Lawrence J. “Review: A Philosophical Interpretation of Nature.” *The Quarterly Review of Biology* 51 (1976): 74-78.

Henderson, Lawrence J. “Teleology in Cosmic Evolution: A Reply to Professor Warren.” *The Journal of Philosophy, Psychology and Scientific Methods* 13 no. 12 (1916): 325-327.

Henderson, Lawrence J. “The Functions of an Environment.” *Science* 39 no. 1006 (1914): 524-527.

Henderson, Lawrence J. “The Locus of Teleology in a Mechanistic Universe.” *The Journal of Philosophy, Psychology and Scientific Methods* 17, no. 16 (1920): 430-436.

Henderson, Lawrence J. “The Practice of Medicine as Applied Sociology.” *Transactions of the Association of American Physicians* 51 (1936): 8-15.

Henderson, Lawrence J. “The Relation of Medicine to the Fundamental Sciences.” *Science* 82, no. 2134 (1935): 477-481.

Henderson, Lawrence J. “The Teleology of Inorganic Nature.” *The Philosophical Review* 25, no. 3 (1916): 265-281.

Henderson, Lawrence J. “Universities and Learned Societies.” *Science* 59, no. 1535 (1924): 477-478.

Henderson, Lawrence J. “The Functions of an Environment.” *Science* 39 (1914): 524-527.

Henderson, Lawrence J. “The Study of Man.” *Science* 94 (1941): 1-10.

Henderson, Lawrence J. *Blood: a Study in General Physiology.* New Haven, CT: Yale University Press, 1928.

Henderson, Lawrence J. *Pareto's General Sociology: a Physiologist's Interpretation.* Cambridge, Harvard University Press, 1935.

Henderson, Lawrence J. *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter*. New York: The Macmillan Company, 1913.

Henderson, Lawrence J. “Blood, A Study in General Physiology.” *New England Journal of Medicine* 199, no. 22 (1928): 1126.

Henderson, Lawrence J. “Blood, A Study in General Physiology.” *Science* (1929).

Henderson, Lawrence J. “Equilibrium in Solution of Phosphates.” *Am. J. Phys.* 15, no. 257 (1906): 270.

Henderson, Lawrence J. “The Heats of Combustion of Atoms and Molecules.” *Phys. Chem.* 9, (1905): 40-56.

Henderson, Lawrence J. “The Physical Chemistry of Milk.” *Journal of Medical Research* 10, no.1 (1903): 127–131.

Henderson, Lawrence J. “The Theory of Neutrality Regulation in the Animal Organism.” *Am. J. Phys*. 21, (1908): 427.

Henderson, Lawrence J. and E.E. Southard, “Education in Medicine: The Relations of the Medical School and the College.” *The Harvard Bulletin* 12, no. 5 (1909): 2.

Henderson, Lawrence J. and Karl Spiro. “Zur Kenntnis des lonengleichgewichts im Organismus. I. Teil. Ueber Basen und Sauregleichgewicht in Harn.” *Biochcm. Ztschr* 15, (1908): 105–113.

Henderson, Lawrence J. and Karl Spiro. “Zur Kenntnis.” *Kolloid Zeitschrift III* 91, (1908):114–122.

Henderson, Lawrence J. *The Order of Nature*. Cambridge, MA: Harvard University Press, 1917.

Henderson, Lawrence J. What is Social Progress?” *Proceedings of the American Academy of Arts and Sciences* 73, no. 15 (1940): 457-463.

Henderson, Lawrence J., C. Gordon and W. L. Harrington. “Natriumchloride und Kadmiumsulfat.” *Ztschr. Phys. Client* 27 (1898): 425.

Henderson, Yandell. “Is This Science or Metaphysics?” *Science* 69, no. 1778 (1929): 39-41.

Holt, Edwin B. “Professor Henderson’s “Fitness” and the Locus of Concepts.” *The Journal of Philosophy, Psychology and Scientific Methods* 17, no. 14, (1920): 365-381.

Homans, George C. and C.P. Curtis, Jr., *An Introduction to Pareto, His Sociology*. New York: A.A. Knopf 1934.

Homans, George C. *Fatigue of Workers Its Relation to Industrial Production*. New York: Reinhold Publishing Corporation, 1941.

Homans, George Caspar. *Coming to My Senses: The Autobiography of a Sociologist*. New Brunswick, NJ: Rutgers University Press, 1984.

Homans, George, and O. T. Bailey. “The Society of Fellows, Harvard University, 1933-1947.” In *The Society of Fellows*, edited by Crane Brinton, 2-7. Cambridge, MA: Society of Fellows, 1959.

King, Judson. “Open Shop at Boulder Dam.” *The New Republic* 67 (1932): 147-148.

Laurence, Todd. “Hoover Dam Called Nest of Anti-Union Exploiters.” *New Leader with Which Is Combined the American Appeal* 15, no. 8 (1933): 10.

Lillie, Ralph S. Review of *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter*, by Lawrence J. Henderson. *Science* 38, no. 975 (1913): 337-342.

Lowell, Abbott Lawrence. *At War With Academic Traditions in America.* Cambridge, MA: Harvard University Press, 1934.

Lowell, Abbott Lawrence *What a University President Has Learned.* New York: Macmillan, 1938.

Lund, Charles C. "The Doctor, the Patient, and the Truth." *Annals of Internal Medicine* 24, no. 6 (1946): 955-959.

Mayo, Elton. *Democracy and Freedom: An Essay in Social Logic.* Melbourne: MacMillan and Co. Ltd, 1919.

Mayo, Elton. "Psychiatry and Sociology in Relation to Social Disorganization." *The American Journal of Sociology* 42, no.6 (1937): 825-831.

Mayo, Elton. "Routine Interaction and the Problem of Collaboration." *American Sociological Review* 4, no. 3 (1939): 335-340.

Mayo, Elton. "The Irrational Factor in Human Behavior. The "Night-Mind" in Industry." *Annals of the American Academy of Political and Social Science* 110 (1923): 117-130.

Mayo, Elton. *The Human Problems of an Industrial Civilization*. New York: Macmillan, 1933.

Mayo, Elton. *The Social Problems of an Industrial Civilization*. Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1945.

Merton, Robert K. "Durkheim's Division of Labor in Society." *The American Journal of Sociology* 40, no. 3 (1934): 319-328.

Merton, Robert K. "Sociological Theory." *The American Journal of Sociology* 50, no. 6 (1945): 462-473.

Merton, Robert K. "The Bearing of Empirical Research upon the Development of Social Theory." *American Sociological Review* 13.5 (1948): 505-515.

Merton, Robert K. *The Focused Interview; a manual*. New York: Columbia University, 1952.

Merton, Robert K. "The Sociology of Knowledge." *Isis* 27, no. 3 (1937): 493-503.

Merton, Robert K. "The Unanticipated Consequences of Purposive Social Action." *American Sociological Review* 1, no. 6 (1936): 894-904.

Minot, George R. "Investigation and Teaching in the Field of the Social Component of Medicine." *Bulletin of the American Association of Medical Social Workers* 10, no. 2 (1937): 9-18.

Minot, George R. “Medical Sociological Aspects in Practice.” *Archives of Internal Medicine* 54, no. 1 (1934): 1-10.

Minot, George R. “The President’s Address.” *Transactions of the Association of American Physicians* 53, (1938): 1-6.

Minot, George R. “The President’s Address.” *Transactions of the Association of American Physicians* 53 (1938): 1-6.

Mitchell, Arthur. Review of *The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter*, by Lawrence J. Henderson. *The Journal of Philosophy, Psychology and Scientific Methods* 10: 691-3.

Montague, W.P. “The Oxford Congress of Philosophy.” *The Journal of Philosophy* 18 (1921): 118-129.

Morgan, Lloyd. *Emergent Evolution: the Gifford Lectures.* London: Williams and Norgate, 1923.

Morgan, Thomas Hunt. *Critique of the Theory of Evolution*. Princeton, NJ: Princeton University Press, 1916.

Parsons, Talcott. “Social Structure and Dynamic Process: The Case of Modern Medical Practice.” In *The Social System*, Talcott Parsons, 428-479. Glencoe, IL: Free Press, 1951.

Parsons, Talcott. *The Structure of Social Action: a Study in Social Theory with Special Reference to a Group of Recent European Writers*. New York: McGraw-Hill Book, 1937.

Parsons, Talcott. *Toward a General Theory of Action*. Cambridge, MA: Harvard University Press, 1951.

Patten, William. *The Grand Strategy of Evolution*. Boston: R. G. Badger, 1920.

Peabody, Francis W. “The Care of the Patient.” *Journal of the American Medical Association* 88 (1927): 877-882.

Pearl, Raymond. “Natural Theology without Theistic Implications.” *The Dial* 55, no. 652 (1913): 111.

Pearl, Raymond. “Science, Metaphysics and Blood.” *Science* 69, no. 1780 (1929): 161-163.

Pearl, Raymond. *Studies in Human Biology*. Baltimore: Williams & Wilkins, 1924.

Perry, Ralph Barton. “Purpose and Systematic Unity.” *The Monist* 27, no. 3 (1917): 352-375.

Reynolds, George P. “The Teaching of the Medicosocial Aspects of Cases.” *The New England Journal of Medicine* 220, no. 1 (1939): 1-7.

Robinson, George C. “Proper Attention to the Role of Emotional and Social Factors in Illness as a New Step in Public Health.” The *Milbank Memorial Fund Quarterly* 23 (1945): 20-27.

Robinson, George C. “The Application of Science to the Practice of Medicine.” *Science* 69 (1929): 459-462.

Robinson, George C. *Patient as a Person.* New York: The Commonwealth Fund and Oxford University Press, 1939.

Roethlisberger, Fritz and W. J. Dickson. *Management and the Worker: An Account of a Research Program Conducted by the Western Electric Company, Hawthorne Works, Chicago.* Cambridge, MA: Harvard University Press, 1939.

Royce, Josiah. *Logical Essays*. Dubuque, Iowa: W. C. Brown Co, 1951.

Royce, Josiah. *The Spirit of Modern Philosophy: An Essay in the Form of Lectures*. New York: Dover, 1983.

Royce, Josiah. “The Mechanical, the Historical and the Statistical.” Science 39 (1914): 551-566.

Royce, Josiah. *Lectures on Modern Idealism*. New Haven, CT: Yale University Press, 1923.

Richards, Dickinson W. “Lawrence Joseph Henderson.” *Physiologist* 1, no. 3 (1958): 32–37.

Sigerist, Henry E. *Socialized Medicine in the Soviet Union*. New York: W.W. Norton, 1937.

Sigerist, Henry. “History in a Tea Wagon.” *Time* 33 (1939): 51-53.

Simon, Abraham J. “Social Structure of Clinics and Patient Improvement.” *Administrative Science Quarterly* 4, no. 2 (1959): 197-206.

Sorokin, Pitirim Aleksandrovich. *Metabolism of Different Strata of Social Institutions and Institutional Continuity.* Roma: Istituto Poligrafico Dello Stato, 1931.

Talbott, John H. “At the Bedside,” *New England Journal of Medicine* 277, no. 3 (1967): 113-114.

Talbott, John H.. “Lawrence Joseph Henderson (1878–1942), Natural Philosopher.” *Journal of the American Medical Association* 198 (1966): 1304–1306.

Thompson, D’Arcy Wentworth. *On Growth and Form.* Cambridge: Cambridge University Press, 1917.

Tillotson, Kenneth J. “Psychobiology in General Medicine.” *The New England Journal of Medicine* 215, no. 4 (1936): 146-149.

Warren, Howard C. “The Study of Purpose. III: The Role of Purpose in Nature.” *Journal of Philosophy, Psychology, and Scientific Methods* 13, no. 3 (1916): 65.

Wheeler, William Morton. *Emergent Evolution and the Development of Societies*. New York: W. W. Norton and Co., 1928.

Whewell, William. *Astronomy and General Physics Considered with Reference to Natural Theology*. London: William Pickering, 1834.

Winslow, Charles E. A. *The Evolution and Significance of the Modern Public Health Campaign.* New Haven, CT: Yale University Press, 1923.

Worcester, Alfred. "Past and Present Methods in the Practice of Medicine." *Boston Medical and Surgical Journal* 176 (1912): 159-164.

"200 Will Die in Building of Boulder Dam: Five Workers Already Give Lives—Labor Conditions May Bring Quis." *New Leader with Which Is Combined the American Appeal* 13 (1931): 2.

"A Symbol of Hooverism: Strikers Demand Decent Food and Drinking Water: Men Die Like Flies at Construction Site." 13, no. 8 (1931): 1.

"California Unions Urge U.S. Take Hoover Dam From Private Company." *New Leader with Which Is Combined the American Appeal* 13, no. 8 (1931): 2.

"Notices and Meetings," *New England Journal of Medicine* 213, no. 21 (1935): 1051-1052.

"Origin of Life: Prof. Henderson, Dualist, Combats Various Theories." *New York Times* (1913): BR155.

"Testimonial Dinner and Meeting in Honor of Dr. David L. Edsall." *The New England Journal of Medicine* 213, no. 17 (1935): 836.

"The Fitness of the Environment." *The Biblical World* 41, no. 4 (1913): 285.

Secondary Sources

Abbott, Andrew. *The Systems of Professions: An Essay on the Division of Expert Labor.* Chicago: University of Chicago Press, 1988.

Abir-Am, Pnina. "The Discourse of Physical Power and Biological Knowledge in the 1930s: A Reappraisal of the Rockefeller Foundation's 'Policy' in Molecular Biology." *Social Studies of Science* 12, no. 3 (1982): 341-382.

Adams, Paul L. "The Influence of New Information from Social Sciences on Concepts, Practice and Research in Child Psychiatry." *Journal of the American Academy of Child Psychiatry* 21, no. 6 (1982): 533-542.

Altschule, Mark D. and Henry K Beecher. *Medicine at Harvard: The First Three Hundred Years.* Hanover, NH: University Press of New England, 1977.

Andrews, Thomas G. *Killing for Coal: America's Deadliest Labor War* (Cambridge, MA: Harvard University Press, 2008.

Badgley, Robin F. and Samuel W. Bloom. “Behavioral Sciences and Medical Education: The Case of Sociology.” *Social Science and Medicine* 7 (1973): 927-941.

Bannister, Robert C. *Sociology and Scientism: The American Quest for Objectivity, 1880-1940*. Chapel Hill: University of North Carolina Press, 1987.

Barber, Bernard. “Introduction.” In Lawrence J. Henderson, *On the Social System: Selected Writings,* edited by Bernard Barber, 1-20. Chicago: University of Chicago, 1970.

Bender, Daniel E. *American Abyss: Savagery and Civilization in the Age of Industry.* Ithaca, NY: Cornell University Press, 2010.

Benison, Saul. *Walter B. Cannon: The Life and Times of a Young Scientist*. Cambridge, MA: Belknap Press, 1987.

Birn, Anne-Emanuelle and Armando Solórzano. “Public Health Policy Paradoxes: Science and Politics in the Rockefeller Foundation’s Hookworm Campaign in Mexico in the 1920s.” *Social Science and Medicine* 49 (1999): 1197-1213.

Birn, Anne-Emanuelle. *Marriage of Convenience: Rockefeller International Health and Revolutionary Mexico.* Rochester, NY: University of Rochester Press, 2006.

Bloom, Samuel William. “Episodes in the Institutionalization of Medical Sociology: A Personal View.” *Journal of Health and Social Behavior* 31, no. 1 (1990): 1-10.

Bloom, Samuel William. *The Word as Scalpel: A History of Medical Sociology*. New York: Oxford University Press, 2002.

Blumgart, Herman L. “Caring for the Patient.” *The New England Journal of Medicine* 270, no. 9 (1964): 449-456.

Bourke, Helen. “Industrial Unrest as Social Pathology: The Australian Writings of Elton Mayo.” *Australian Historical Review* 20 (1982): 217-233.

Bourricaud, Francois. *The Sociology of Talcott Parsons*. Chicago: University of Chicago, 1984.

Bragg, Sir William. *Concerning the Nature of Things: Six Lectures Delivered at the Royal Institution.* London: G. Bell and Sons, 1925.

Braverman, Harry. *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century*. New York: Monthly Review Press, 1974.

Breen, William J. “Social Science and State Policy in World War II: Human Relations, Pedagogy, and Industrial Training, 1940-1945.” *The Business History Review* 76, no. 2 (2002): 233-266.

Brick, Howard. “Talcott Parsons' "Shift Away from Economics, 1937-1946.” *The Journal of American History* 87, no. 2 (2000): 490-514.

Brick, Howard. *Transcending Capitalism: Visions of a New Society in Modern American Thought*. Ithaca: Cornell University Press, 2006.

Brickman, Jane Pacht. "Science and the Education of Physicians: Sigerist's Contribution to American Medical Reform." 15 (1994): 133-164.

Brody, David. *Steelworkers in America: The Nonunion Era*, rev. ed., Urbana: University of Illinois Press, 1998.

Brown, E. Richard. *Rockefeller Medicine Men: Medicine and Capitalism in America*. Berkeley: University of California Press, 1979.

Brown, JoAnne. *The Definition of a Profession: The Authority of Metaphor in the History of Intelligence Testing, 1890-1930*. Princeton, N.J: Princeton University Press, 1992.

Burawoy, Michael. *Manufacturing Consent: Changes in the Labor Process Under Monopoly Capitalism*. Chicago: University of Chicago Press, 1979.

Butler, Stella V. F. "Centers and Peripheries: The Development of British Physiology, 1870-1914." *Journal of the History of Biology* 21.3 (1988): 473-500.

Camic, Charles. "The Making of a Method: A Historical Reinterpretation of the Early Parsons." *American Sociological Review* 52, no. 4 (1987): 421-439.

Canguilhem, Georges. *The Normal and the Pathological*. trans. Carolyn R. Fawcett and Robert S. Cohen. New York: Zone Books, 1998.

Clendenning, John. *The Life and Thought of Josiah Royce*, rev. ed. Nashville: Vanderbilt University Press, 1999.

Cohen, I. Bernard. "A Harvard Education." *Isis* 75, no. 1 (1984): 13-21.

Cohen, I. Bernard. *Interactions: Some Contacts Between the Natural Sciences and the Social Sciences*. Cambridge, MA: MIT Press, 1994.

Cohen, Lizbeth. *Making a New Deal: Industrial Workers in Chicago, 1919-1939*. Cambridge: Cambridge University Press, 1990.

Cosman, Bard C. "The Human Factor: The Harvard Fatigue Laboratory and the Transformation of Taylorism." Undergraduate thesis, Harvard University, 1983.

Cot, Annie L. "A 1930s North American Creative Community: The Harvard "Pareto Circle." *History of Political Economy* 43, no. 1 (2011): 131-159;

Crenner, Christopher. *Private Practice in the Early Twentieth-century Medical Office of Dr. Richard Cabot*. Baltimore: The Johns Hopkins University Press, 2005.

Crenner, Christopher. *Private Practice In the Early Twentieth-Century Medical Office of Dr. Richard Cabot.* Baltimore, MD: The Johns Hopkins University Press, 2005.

Cross, Stephen J., and William R. Albury. “Walter B. Cannon, L. J. Henderson, and the Organic Analogy.” *Osiris* 3 (1987): 165-192.

Crowther-Heyck, Hunter. “Patrons of the Revolution: Ideals and Institutions in Postwar Behavioral Science.” *Isis* 97.3 (2006): 420-446.

Cruikshank, Jeffrey L. *A Delicate Experiment: The Harvard Business School, 1908-1945.* Boston, Mass: Harvard Business School Press, 1987.

Cueto, Marcos. "Visions of Science and Development: The Rockefeller Foundation's Latin American Surveys of the 1920s." In *Missionaries of Science*, edited by Marcos Cueto, 7-13. Bloomington, Indiana, 1994.

Cueto, Marcos. “Science under Adversity: Latin American Medical Research and American Private Philanthropy, 1920-1960.” *Minerva* 35 (1997): 233-245.

Cueto, Marcos. “The Rockefeller Foundation's Medical Policy and Scientific Research in Latin America: The Case of Physiology.” *Social Studies of Science* 20, no. 2 (1990): 229-254.

Cullather, N. “The Foreign Policy of the Calorie.” *The American Historical Review* 112, no. 2 (2007): 337–364.

Daston, Lorraine and Peter Galison. *Objectivity*. New York: Zone Books, 2007.

Dawley, Alan. *Struggles for Justice: Social Responsibility and the Liberal State*. Cambridge, MA: Belknap Press of Harvard University Press, 1991.

Dick, Stephen J. *Life on Other Worlds: The 20th-Century Extraterrestrial Life Debate*. Cambridge: Cambridge University Press, 1998.

Ebert, Robert H. “Medical Education in the United States.” *Daedalus* 106, no. 1 (1977): 171–184.

Edsall, John.T. “Some Personal History and Reflections from the Life of a Biochemist.” *Biophysical Chemistry* 100 (2003): 1-29.

Edsall, John T. “Blood and Hemoglobin: The Evolution of Knowledge of Functional Adaptation in a Biochemical System. Part I: The Adaptation of Chemical Structure to Function in Hemoglobin.” *Journal of the History of Biology* 5, no. 2 (1972): 205–257.

Elliott, Clark A. and Margaret W. Rossiter, editors. *Science at Harvard University: Historical Perspectives*. Bethlehem, PA: Lehigh University Press, 1992.

Evesham, H.A. *The History and Development of Nomography*. Boston: Docent Press, 1982.

Fisher, Donald. “American Philanthropy and the Social Sciences in Britain, 1919-1939: The Reproduction of a Conservative Ideology.” *The Sociological Review* 23, no. 2 (1980): 277-315.

Fisher, Donald. “The Role of Philanthropic Foundations in the Reproduction and Production of Hegemony: Rockefeller Foundations and the Social Sciences.” *Sociology* 17 (1983): 206-236.

Foucault, Michel. *Madness and Civilization: A History of Insanity in the Age of Reason. Translated by Richard Howard*. New York: Vintage, 1988. First published in United States in 1965 by Pantheon.

Foucault, Michel. Madness and Civilization: A History of Insanity in the Age of Reason, translated by Richard Howard. New York: Vintage, 1965.

Foucault, Michel. *The History of Sexuality: An Introduction Volume 1*. New York: Vintage Press, 1978.

Fruton, Joseph S. “Contrast in Scientific Style. Emil Fischer and Franz Hofmeister: Their Research Groups and Theory of Protein Structure.” *Proceedings of the American Philosophical Society* 129, no. 4 (1985): 313–370.

Fry, Iris. “Evolution in the Thermodynamic Perspective: A Historical and Philosophical Angle.” *Zygon* 30 (1995): 227-248.

Fry, Iris. “On the Biological Significance of the Properties of Matter: L.J. Henderson’s Theory of the Fitness of the Environment.” *Journal of the History of Biology* 29, no. 2 (1996): 155-196.

Fry, Iris. *The Emergence of Life on Earth: A Historical and Scientific Overview*. New Brunswick, NJ: Rutgers University Press, 2000.

Furner, Mary O. *Advocacy & Objectivity: A Crisis in the Professionalization of American Social Science, 1865-1905*. Lexington: University Press of Kentucky, 1975.

Gabor, Andrea. *The Capitalist Philosophers: The Geniuses of Modern Business, Their Lives, Times and Ideas*. New York: Times Business, 2000.

Galambos, Louis. “The Emerging Organizational Synthesis in Modern American History.” *The Business History Review* 44, no. 3 (1970): 279-290.

Geiger, Roger L. *To Advance Knowledge: The Growth of American Research Universities, 1900-1940*. Oxford: Oxford University Press, 1986.

Geison, Gerald L. “'Divided We Stand': Physiologists and Clinicians in the American Context.” In *The Therapeutic Revolution: Essays in the Social History of American Medicine,* edited by Morris J. Vogel and Charles E. Rosenberg, 67–90. Philadelphia: University of Pennsylvania, 1979.

Geison, Gerald L., editor. *Physiology in the American Context: 1850–1940*. Baltimore: Lippincott Williams and Wilkins, 1987.

Gerhardt, Uta. *Talcott Parsons: An Intellectual Biography*. Cambridge: Cambridge University Press, 2002.

Gerle, Bo, Gerd Lunden, and Philip Sandblom. "The Patient with Inoperable Cancer from the Psychiatric and Social Standpoints." *Cancer* 13, no. 6 (1960): 1206-1217.

Gerstle, Gary. *American Crucible: Race and Nation in the Twentieth Century*. Princeton, NJ: Princeton University Press, 2001.

Gillespie, Richard Pearson. *Manufacturing Knowledge: A History of the Hawthorne Experiments*. Cambridge: Cambridge University Press, 1991.

Gilman, Nils. *Mandarins of the Future: Modernization Theory in Cold War America*. Baltimore: The Johns Hopkins University Press, 2007.

Goffman, Erving. *Asylums: Essays on the Social Situation of Mental Patients and Other Inmates*. Garden City, NY: Anchor Books, 1961.

Gutman, Herbert. "Work, Culture, and Society in Industrializing America, 1815-1919." *American Historical Review* 78, no. 4 (1973): 531-588.

Habenstein, Robert W. "Critique of 'Profession' as a Sociological Category." *The Sociological Quarterly* 4, no. 4 (1963): 291-300.

Hamilton Cravens and John C. Burnham. "Psychology and Evolutionary Naturalism in American Thought, 1890-1940." *American Quarterly* 23, no.5 (1971): 635-657.

Hankins, Thomas L. "Blood, Dirt, and Nomograms: A Particular History of Graphs." *Isis* 90, no. 1 (1999): 50-80.

Haraway, Donna J. *Modest_Witness@Second_Millennium. FemaleMan©_Meets_OncoMouse™*. New York: Routledge, 1997.

Harrington, Ann. "Metaphoric Connections: Holistic Science in the Shadow of the Third Reich," *Social Research* 62, no.2 (1995):357-385.

Harvey, Joy. "History of Science, History and Science, and Natural Sciences: Undergraduate Teaching of the History of Science at Harvard, 1938-1970." *Isis* 90 (1999): S270-S294.

Haskell, Thomas L. *The Emergence of Professional Social Science: The American Social Science Association and the Nineteenth-Century Crisis of Authority*. Urbana: University of Illinois Press, 1977.

Heptinstall, Robert H. "Ivory Tower Humanist." *The New England Journal of Medicine* 289, no. 16 (1973): 862-863.

Herman, Ellen. *The Romance of American Psychology: Political Culture in the Age of Experts*. Berkeley: University of California Press, 1995.

Heyl, B. S. “The Harvard “Pareto Circle.”” *Journal of the History of the Behavioral Sciences* 4, no. 4 (1968): 316–334.

Hoffman, Charles. “The Depression of the Nineties.” *The Journal of Economic History* 16, no. 2 (1956): 137–164.

Horvath, Steven M. *The Harvard Fatigue Laboratory: Its History and Contributions*. Englewood Cliffs, N.J: Prentice-Hall, 1973.

Hudson, Robert P. “Abraham Flexner in Perspective: American Medical Education, 1865-1910.” In *Sickness and Health in America: Readings in the History of Medicine and Public Health*, edited by Judith Walter Leavitt and Ronald L. Numbers, 200-210. Madison: University of Wisconsin Press, 1978.

Igo, Sarah Elizabeth. *The Averaged American: Surveys, Citizens, and the Making of a Mass Public*. Cambridge, MA: Harvard University Press, 2007.

Isaac, Joel. “Tangled Loops: Theory, History, and the Human Sciences in Modern America.” *Modern Intellectual History* 6, no. 2 (2009): 397-424.

Isaac, Joel. “Theorist at Work: Talcott Parsons and the Carnegie Project on Theory, 1949–1951.” *Journal of the History of Ideas* 71, no. 2 (2010): 287-311.

Isaac, Joel. “The Harvard Pareto Circle revisited.” Paper presented at the Seminar in Political Thought and Intellectual History, University of Cambridge, Cambridge, UK, October, 2008.

Isaac, Joel. *Working Knowledge: Making the Human Sciences from Parsons to Kuhn.* Cambridge, MA: Harvard University Press, 2012.

Jordan, John M. *Machine-Age Ideology: Social Engineering and American Liberalism, 1911-1939*. Chapel Hill: University of North Carolina Press, 1994.

Kay, Lily E. *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology*. New York: Oxford University Press, 1993.

Kay, Lily E. *Who Wrote the Book of Life?: A History of the Genetic Code*. Palo Alto, CA: Stanford University Press, 2000.

Keller, R. T. “The Harvard" Pareto Circle" and the Historical Development of Organization Theory.” *Journal of Management* 10, no. 2 (1984): 193.

Kennedy, David M. *Over Here: The First World War and American Society*. New York: Oxford University Press, 1980.

Kessler-Harris, Alice. *Gendering Labor History*. Urbana: University of Illinois Press, 2006.

Kevles, Daniel J., and Gerald L. Geison. “The Experimental Life Sciences in the Twentieth Century.” *Osiris* 10 (1995): 97-121.

Klein, Herbert S. *A Population History of the United States.* Cambridge: Cambridge University Press, 2012.

Kohler, Robert E. “The History of Biochemistry: A Survey.” *Journal of the History of Biology* 8, no. 2 (1975): 275–318.

Kohler, Robert E. *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline*. Cambridge: Cambridge University Press, 1982.

Kohler, Robert E. *Partners in Science: Foundations and Natural Scientists, 1900-1945*. Chicago: University of Chicago Press, 1991.

Lave, Jean and Etienne Wenger. *Situated Learning: Legitimate Peripheral Participation.* Cambridge, England: Cambridge University Press, 1991.

Lawrence, Christopher, and George Weisz, editors. *Greater Than the Parts: Holism in Biomedicine, 1920-1950*. Oxford: Oxford University Press, 1998.

Lee, Young Kuk. “Political Homeostasis: Walter B. Cannon's Organic Analogy and Depression America.” PhD diss., Harvard University, 1999.

Lemov, Rebecca M. *World as Laboratory: Experiments with Mice, Mazes, and Men*. New York: Hill and Wang, 2005.

Lowenstein, Jerome. *Henderson's Equation: A Novel*. Great Barrington, MA: Gadd & Co. Publishers, 2008.

Löwy, Ilana. “Historiography of Biomedicine: ‘Bio,’ ‘Medicine,’ and In Between.” *Isis* 102, no. 1 (2011): 116–122.

Lucier, Paul. “The Origins of Pure and Applied Science in Gilded Age America.” *Isis* 103, no. 3 (2012): 527-536.

Ludmerer, Kenneth M. *Learning to Heal: The Development of American Medical Education.* New York: Basic Books, 1985.

Mahner, Martin, and Mario Bunge. “Function and Functionalism: A Synthetic Perspective.” *Philosophy of Science* 68, no. 1 (2001): 75-94.

Malkin, Harold M. “Concept of Acid-Base Balance in Medicine.” *Annals of Clinical & Laboratory Science* 33, no. 2 (2003): 337–345.

Mayer, Jean. “Lawrence J. Henderson.” *Journal of Nutrition* 94 (1968): 1–5.

Mendelsohn, Everett. “Locating “Fitness” and L.J. Henderson.” In *Fitness of the Cosmos for Life: Biochemistry and Fine-Tuning*, edited by John D. Darrow, Conway Morris, Stephen

J. Freeland, and Charles L. Harper, Jr., 3–19. Cambridge: Cambridge University Press, 2008.

Moody, J. Carroll and Alice Kessler-Harris. *Perspectives on American Labor History: The Problems of Synthesis.* DeKalb: Northern Illinois University Press, 1989.

Morawski, J. G. "Organizing Knowledge and Behavior at Yale's Institute of Human Relations." *Isis* 77, no. 2 (1986): 219-242.

Morison, Samuel Eliot. *Three Centuries of Harvard, 1636-1936*. Cambridge, MA: Harvard University Press, 1965.

Nye, Robert A. "The Bio-Medical Origins of Urban Sociology." *Journal of Contemporary History* 20, no. 4 (1985): 659-675.

O'Connor, Ellen S. "The Politics of Management Thought: A Case Study of the Harvard Business School and the Human Relations School." *The Academy of Management Review* 24, no. 1 (1999): 117-131.

Ogburn, William F. "Cultural Lag as Theory." *Sociology & Social Research* 41, no.3 (1957): 167–174.

Ogburn, William F. *Social Change with Respect to Culture and Original Nature*. Oxford: Oxford University Press, 1966.

Oppenheim, Frank M. *Reverence for the Relations of Life: Re-Imagining Pragmatism Via Josiah Royce's Interactions with Peirce, James, and Dewey*. Notre Dame, IN: University of Notre Dame Press, 2005.

Owens, Robert B. "Producing Parsons' Reputation: Early Critiques of Talcott Parsons' Social Theory and the Making of a Caricature." *Journal of the History of Behavioral Sciences* 46, no. 2 (2010): 165-188.

Parascandola, John. "Henderson, Lawrence Joseph." *American National Biography Online* 26, Oct. (2010).

Parascandola, John. "Lawrence J. Henderson and the Concept of Organized Systems." PhD diss., Harvard University, 1968.

Parascandola, John. "Organismic and Holistic Concepts in the Thought of L. J. Henderson." *Journal of the History of Biology* 4, no. 1 (1971): 63-113.

Parmar, Inderjeet. *Foundations of the American Century: The Ford, Carnegie, and Rockefeller Foundations in the Rise of American Power.* New York: Columbia University Press, 2012.

Paul Starr. *The Social Transformation of American Medicine.* New York: Basic Books, 1982.

Pauly, Philip. *Controlling Life: Jacques Loeb and the Engineering Ideal in Biology.* Oxford: Oxford University Press, 1987.

Porter, Dorothy. "How Did Social Medicine Evolve, and Where Is It Heading?" *PLoS Med* 3 (2006): 399.

Pressman, Jack D. "Human Understanding: Psychosomatic Medicine and the Mission of the Rockefeller Foundation." in *Greater Than the Parts: Holism in Biomedicine, 1920–1950*, edited by Christopher Lawrence and George Weisz. Oxford: Oxford University Press, 1998.

Pyun, Tuk-Sang. "Science, Social Science, and Society: Natural Images in Talcott Parsons's Social Theory." PhD diss., Harvard University, 2002.

Rabinbach, Anson. *The Human Motor: Energy, Fatigue, and the Origins of Modernity.* Berkeley: University of California Press, 1990.

Reuben, Julie. *Making of the Modern University: Intellectual Transformation and the Marginalization of Morality*. Chicago: University of Chicago Press, 1996.

Reynolds, Andrew. "The Theory of the Cell State and the Question of Cell Autonomy in Nineteenth and Early Twentieth-Century Biology." *Science in Context* 20, no. 1 (2007): 71–95.

Rezneck, Samuel. "Unemployment, Unrest, and Relief in the United States During the Depression of 1893–97." *Journal of Political Economy* 61, no. 4 (1953): 324–345.

Roethlisberger, F. J. *The Elusive Phenomena: An Autobiographical Account of My Work in the Field of Organizational Behavior at the Harvard Business School*. Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1977.

Rosenberg, Charles E. *Explaining Epidemics and Other Studies in the History of Medicine.* Cambridge: Universty of Cambridge, 1992.

Rosenberg, Charles E. *No Other Gods: On Science and American Social Thought*. rev. ed. Baltimore: The Johns Hopkins University Press, 1997.

Rosenberg, Charles E. *Our Present Complaint*. Baltimore: Johns Hopkins University Press, 2007.

Rosenberg, Charles E. *The Care of Strangers: The Rise of America's Hospital System*. Baltimore: Johns Hopkins University Press, 1995.

Rosenberg, Charles. "Holism in Twentieth-Century Medicine," in *Greater Than the Parts; Holism in Biomedicine, 1920-1950*, Christopher Lawrence and George Weisz, eds. (Oxford, UK, 1998): 335-336;

Ross, Dorothy. *The Origins of American Social Science*. Cambridge: Cambridge University Press, 1991.

Rossini, Frederick D. *Fundamental Measures and Constants for Science and Technology*. Cleveland, OH: CRC Press, 1974.

Russett, Cynthia Eagle. *The Concept of Equilibrium in American Social Thought*. New Haven, CT: Yale University Press, 1966.

Sapp, Jan. *Genesis: The Evolution of Biology*. Oxford: Oxford University Press, 2003.

Scheffler, Robin. "The Fate of a Progressive Science: The Harvard Fatigue Laboratory, Athletes, the Science of Work and the Politics of Reform." *Endeavour* 35, no. 2–3 (2011): 48–54.

Schelar, Virginia M. "Thermochemistry and the Third Law of Thermodynamics." *Chymia* 11 (1966): 99-124.

Schloegel, Judy Johns, and Henning Schmidgen. "General Physiology, Experimental Psychology, and Evolutionism: Unicellular Organisms as Objects of Psychophysiological Research, 1877-1918." *Isis* 93, no. 4 (2002): 614-645.

Schneider, William H. "The Scientific Study of Labor in Interwar France." *French Historical Studies* 17, no. 2 (1991): 410-446.

Scott, William G. *Chester I. Barnard and the Guardians of the Managerial State*. Lawrence: University Press of Kansas, 1992.

Shapin, Steven. "Review: Mertonian Concessions." *Science* 259, no. 5096 (1993): 839-841.

Shapin, Steven. "Understanding the Merton thesis." *Isis* 79, no. 4 (1988): 594–605.

Shapin, Steven. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental*. Princeton, NJ: Princeton University Press, 1989.

Smith, J. H. "The Enduring Legacy of Elton Mayo." *Human Relations* 51 (1998): 221-249.

Smith, Mark C. *Social Science in the Crucible: The American Debate Over Objectivity and Purpose, 1918-1941*. Durham, NC: Duke University Press, 1994.

Smith, Roger. "Biology and Values in Interwar Britain: C. S. Sherrington, Julian Huxley and the Vision of Progress." *Past & Present* 178 (2003): 210-242.

Smith, Roger. *The Norton History of the Human Sciences*. New York: W.W. Norton and Co., 1997.

Solovey, Mark and Hamilton Cravens, editors. *Cold War Social Science: Knowledge Production, Liberal Democracy, and Human Nature.* New York: Palgrave MacMillan, 2012.

Starr, Paul. *The Social Transformation of American Medicine*. New York: Basic Books, 1982.

Stevens, Joseph E. *Hoover Dam: An American Adventure.* Norman, OK: University of Oklahoma Press, 1990.

Stevens, Rosemary. *Medical Practice in Modern England: the Impact of Specialization and State Medicine.* New Haven, CT: Transaction Publishers, 1966.

Stocking, George W. "Lamarckianism in American Social Science: 1890-1915." *Journal of the History of Ideas* 23, no. 2 (1962): 239-256.

Sturdy, Steve. "Biology as Social Theory: John Scott Haldane and Physiological Regulation." *The British Journal for the History of Science* 21, no. 3 (1988): 315-340.

Szasz, Thomas S. *The Myth of Mental Illness: Foundations of a Theory of Personal Conduct.* New York: Hoeber-Harper Press, 1961.

Thackray, Arnold. "The Pre-History of an Academic Discipline: The Study of the History of Science in the United States, 1891–1941." In *Transformation and Tradition in the Sciences: Essays in Honor of I. Bernard Cohen*, edited by Everett Mendelsohn, 395-420. Cambridge: Cambridge University Press, 1984.

Haskell, Thomas L. *The Authority of Experts: Studies in History and Theory*. Bloomington: Indiana University Press, 1984.

Tracy, Sarah W. "The Physiology of the Extremes: Ancel Keys and the International High Altitude Expedition of 1935." *Bulletin of the History of Medicine* 86 (2012): 627-660.

Tracy, Sarah. "An Evolving Science of Man: The Transformation and Demise of American Constitutional medicine, 1920-1950." In *Greater Than the Parts: Holism in Biomedicine, 1920-1950*, edited by Christopher Lawrence and George Weisz, 161-188. Oxford: Oxford Universty Press, 1998.

Tracy, Sarah. "George Draper and American Constitutional Medicine, 1916-1946," *Bulletin of the History of Medicine* 66, no.1 (1992): 53-89;

Trahair, R. C. S. *The Humanist Temper: The Life and Work of Elton Mayo*. New Brunswick, NJ: Rutgers University Press, 1984.

Turner, Bryan S. *Medical Power and Social Knowledge*. 2nd ed. London: Sage Publications, 1995.

Viseltear, A. J. "Milton C. Winternitz and the Yale Institute of Human Relations: A Brief Chapter in the History of Social Medicine." *The Yale Journal of Biology and Medicine* 57, no. 6 (1984): 869.

Viseltear, A. J. "The Yale Plan of Medical Education: The Early Years." *The Yale Journal of Biology and Medicine* 59, no. 6 (1986): 627.

Vogel, Morris J. *The Invention of the Modern Hospital, Boston, 1870-1930.* Chicago: University of Chicago Press, 1980.

Warner, John Harley. "Physiology." In *The Education of American Physicians: Historical Essays*, edited by Ronald L. Numbers. Berkeley: University of California Press, 1980.

Warner, John Harley. "Science in Medicine." In *Historical Writings in American Science: Perspectives and Prospects*, edited by Sally Gregory Kohlstedt and Margaret W. Rossiter, 37-58. Baltimore: Johns Hopkins University Press, 1985.

Warner, John Harley. *Against the Spirit of System*. Princeton, NJ: Princeton University Press, 1998.

Weisz, George. *Divide and Conquer: A Comparative History of Medical Specialization*. Oxford: Oxford University Press, 2005.

Weller, Sol W. "Napoleon Bonaparte, French Scientists, Chemical Equilibrium, and Mass Action." *Bulletin for the History of Chemistry* 24 (1999): 61–66.

Whitehead, Alfred N. *Science and the Modern World*. New York: Macmillan, 1925.

Wiebe, Robert H. *The Search for Order, 1877-1920*. New York: Hill and Wang, 1966.

Wolf, William B. "Chester I. Barnard (1886-1961)." *The Journal of the Academy of Management* 4, no. 3 (1961): 167-173.

Wolf, William B. *The Basic Barnard: An Introduction to Chester I. Barnard and His Theories of Organization and Management*. Ithaca, NY: Industrial and Labor Relations, 1974.

Wolfe, Elin L. *Walter B. Cannon, Science and Society*. Cambridge, MA: Harvard University Press, 2000.

Yeomans, Henry Aaron. *Abbott Lawrence Lowell, 1856–1943.* Cambridge, MA: Harvard University Press, 1977.

Steinmetz, George. *The Politics of Method in the Human Sciences: Positivism and Its Epistemological Others*, (Durham, NC: Duke University Press, 2005).