ECOLOGICAL THOUGHT AT

THE INTERNATIONAL CONGRESS OF ARTS AND SCIENCE, 1904

A Thesis Submitted to the College of
Graduate Studies and Research
In Partial Fulfillment of the Requirements
For the Degree of Doctor of Philosophy
In the Department of History
University of Saskatchewan
Saskatoon

By

JENNIFER LEIGH HANSEN

PERMISSION TO USE

In presenting this thesis/dissertation in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis/dissertation in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis/dissertation work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis/dissertation or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis/dissertation.

Requests for permission to copy or to make other uses of materials in this thesis/dissertation in whole or part should be addressed to:

Head of the Department of History
9 Campus Drive
University of Saskatchewan
Saskatoon, Saskatchewan S7N 5A5 Canada

OR

Dean
College of Graduate Studies and Research
University of Saskatchewan
107 Administration Place
Saskatoon, Saskatchewan S7N 5A2 Canada

ABSTRACT

Ecological thought shows remarkable continuity since 1800. Personal connections provide the groundwork for this cohesion. The emergence of ecological thought involved hundreds of individuals exchanging ideas through letters, publishing studies, and by participating in academic events. These links appear in sufficient numbers that it is clear ecology functioned as a vibrant network long before it was a viable scientific field. This dissertation examines ecological thought during the long nineteenth century, using the proceedings of the International Congress of Arts and Science, 1904 (ICAS) as an entry point. The ICAS was hosted during a universal fair that commemorated the Louisiana Purchase (1803). In light of the reflective atmosphere, participants were asked to comment on the development of their respective fields over the previous century and to explain to their audience how their fields related to contemporary science. This exercise provides historians with a unique primary source. The proceedings became, in effect, an accidental survey administered to leading scientists at the turn of the century concerning how academic science was practiced and who they considered to be the most important influences in their fields. Ecological thinking is evident in many of the life science presentations at the ICAS, and studying the proceedings constitutes an excellent opportunity to better understand and appreciate how ecological thinking became a force in modern Western society.

ACKNOWLEDGMENTS

First and foremost, my thanks goes to my supervisor, Dr. Bill Waiser, for his ongoing guidance and unfailing good humour. I am indebted to my dissertation committee for the expertise and positive support they have provided. Dr. Martha Smith-Norris served as my Graduate Director, my boss, and a committee member for the past two years. Dr. Larry Stewart, my former MA advisor, contributed extensive advice and direction during the research phase. Dr. Dan Pennock offered fresh insights and much-needed confidence. Many thanks go to Dr. Melanie Frappier for serving as the external examiner and offering a close reading and helpful commentary.

I would like to acknowledge the staff at the following archives for their assistance: The National Archives at Kew, The London Metropolitan Archives, the Bodleian Libraries at Oxford University, the National Archives of Scotland, and Archive Services at the University of Glasgow. I would also like to express my appreciation to the staff at Interlibrary Loans at the University of Saskatchewan, and offer a special thanks to Nadine Penner with the College of Arts and Science for her assistance in completing the administrative requirements of the program. Financial assistance was received from a Social Sciences and Humanities Research Doctoral Fellowship, a College of Graduate Studies Dean's Scholarship, and Research Fellowships and travel bursaries through the Department of History.

My personal network includes many colleagues from the Department of History, past and present, that have offered community, friendship, and support. Kim, Jillian, Mandy, Merle, and Marley, I am grateful for the many hours of coffee and commiseration. Finally, my family is my world and my foundation. Many thanks to my father, Ted, and my children, Emma, Katherine, and Simon, for their considerable patience and understanding during this process. Above all, I would like to acknowledge my mother, Elly Hansen (nee Wudrick), who grew up German in the West but was for a long time discouraged from exploring that heritage. Her support for me in this undertaking, and everything else, has been overwhelming. This one is for you, Mum.

CONTENTS page

FIGURES

ACRONYMS

AAAS	American Association for the Advancement of Science
BAAS	British Association for the Advancement of Science
FR	Francs
GBP	British Pound
GHGs	Greenhouse Gas Emissions
GSL	Geological Society of London
ICAS	International Congress of Arts and Science, 1904
IGS	International Geographical Society
IPCC	Intergovernmental Panel on Climate Change
LPE	Louisiana Purchase Exposition
ℳ	German Goldmark
USA	United States of America
USD	United States Dollars
USDA	United States Department of Agriculture

Here it is time to pause and reflect. The events about to be chronicled, so charged with genuine enthusiasm and earnest aspirations at the time of their happening, are not only obscured but distorted when looked at in the light of the time of the present writing. Enthusiasm turns to irony, ideals into empty bubbles. It is the task of the humblest historian, however, to present the past untarnished by the events that followed.

-Hugo Münsterberg, "The Scientific Plan of the Congress"

CHAPTER ONE

HISTORY OF ECOLOGY: FRAMEWORK AND OVERVIEW

Ecology is a social creature. Birthed in a specific historical and geographical context, it has adapted and transmutated over time. In the broadest sense, ecological thought takes several forms. Scientific ecology, the study of interactions among organisms (including humans) and their environment, is an interdisciplinary field that incorporates aspects of biology, geography, and geology. The studies often inform political discussion of environmental topics, such as biodiversity and climate change. Ecologists may be politically-oriented individuals, but do not see their field as an inherently political discipline. Ecologism, by contrast, is a political ideology that takes the position that the non-human world is worthy of moral consideration and should be reflected in social, economic, and political systems. Like scientific ecology, ecologism can be studied at the academic level, but its home is typically the philosophy department rather than within the sciences. Environmentalism, by contrast, is a social movement that is concerned with protection and / or rehabilitation of the global environment. The intellectual divisions within ecological thought are contentious. What constituted an apolitical position on climate change forty years ago, for example, looks very different since the rise of the Intergovernmental Panel on Climate Change (IPCC). The multiplicity of approaches within the ecological world view is often mistakenly presumed to have emerged out of an explosion of environmental thought and political discourse during the second half of the twentieth century. On the contrary, methodological and philosophical diversity has been a feature of ecological thought since its inception, near the beginning of the nineteenth century.

Personal connections provide the cohesion for the discipline. The emergence of ecological thought involved hundreds of individuals exchanging ideas by sending letters, publishing studies, and participating in academic events. Through these many connections, ecology clearly functioned as a vibrant network long before it was a viable scientific field.[1] Continuity is also found in the mixture of science and politics—not in any particular political outlook, but simply because a combination existed at all. The philosophical outlook of participants in the early ecology network was affected by their social and political realities, which in turn influenced their intellectual inquiries, just as ecologists today are affected by their own social context. Recent commentary regarding species extinction typically blames industrial capitalism, just as investigators of the nineteenth century accepted that rapid human industrialization and civilization was a form of

1 The period preceding formalized, professional scientific ecology is sometimes referred to as proto-ecology. The term implies a demotion or dismissal of other academic work on ecology, including philosophical and political understandings, and the emphasis on professionalization not only diminishes the contributions of amateur ecologists, but also the impact of public awareness. For these reasons, "proto" or "pre" ecology will not be a concept incorporated into this discussion.

improvement. Fundamentally, ecologists were interested in the relationship between organisms and their environment in both instances. Finally, scientific ecology has always demonstrated a tension between specialization and interdisciplinary thinking. Ecologists developed their ideas by conversing with specialists in other disciplines, as well as experts in non-academic fields. At the same time, they have struggled to assert their own independence within the hierarchy of science. Although the development of ecology has been remarkably consistent in three ways—personal connections, politico-social susceptibility, and the need for both interdisciplinarity and independence—the ethical framework has shifted. It can be argued the blending of anti-industrial ethics and ecology that occurred in the 1960s was so traumatic that it created a new modernized interdisciplinary field. The past has haunted ecology, however, just as it does in other scientific disciplines. True modernity will elude the discipline until the challenges of today are reconciled with inherited traditions.

Foremost among these traditions is personal collaboration between academics. In the nineteenth century, scientific fields like ecology were promoted through the circulation of textbooks and journals, but personal connections between investigators remained the primary method of expanding the discipline. Many of these connections were made during research trips. Networks of intellectuals were strengthened by international students in university programs and participation in prestigious conferences and congresses. Ecology was included as a field for the first time at the International Congress of Arts and Science (ICAS), held in 1904 at the Louisiana Purchase Exposition (LPE) in St. Louis, Missouri. The ICAS did not directly promote ecology or ecological thinking to the public in a self-conscious manner, as would be typical during the climate change and biodiversity discussions a century later. Instead, organizers brought media attention to scientific academic progress through summaries provided in the event proceedings, through lecture reprints, and above all, through press coverage of high-profile evening receptions held at Festival Hall and pavilions throughout the week.

What follows is an examination of ecological thought during the long nineteenth century, using the ICAS proceedings as an entry point. The ICAS was hosted during a universal fair that commemorated the Louisiana Purchase (1803). In light of the reflective atmosphere, participants were asked to comment on the development of their respective fields over the previous century and to explain how their fields contributed to contemporary science. This exercise has provided historians with a unique primary source. The proceedings became, in effect, an accidental survey administered to leading scientists at the turn of the century. Participants commented on how academic science was practiced and who they considered to be the most important influences in their field. Ecological thinking is evident in many of the ICAS life science presentations. The proceedings offer an excellent opportunity to better understand and appreciate how ecological thinking became a force in modern western society.

The ICAS is an especially suitable entry point to map out the early ecology social network because ecology, like all science, has always been an international endeavor. Although the present study involves the history of science, it is best described as an example of world history, using Patrick Manning's definition of world history as "the story of connections within the global human community."[2] The ICAS is an example of one instance where connections were made within the development of the field. The conference was led by the American government and it succeeded in temporarily linking the governments of several imperial systems in a major effort to encourage the diffusion of knowledge. It also celebrated knowledge exchanges that were already established, since the academic community at the professorial level was already palpably internationalized and functioned as the research sector for a globalizing world system.

Delegates at the ICAS represented their nations, but were a self-conscious international community of scholars. Historian Sally Kohlstedt has identified nationalism as a hallmark of the nineteenth century. She argued for a uniquely American ecology, suggesting that Americans drew upon their reputation as "ingenious Yankees" when they sought to develop a science that would compare well with intellectual accomplishments in Europe.[3] Kohlstedt may be correct in most aspects of her characterization of the American node of ecology, but nationalist histories can only tell one aspect of the grander project. As historian John Darwin has noted, links forged by migrations and the flows of goods and ideas retreat into the margins or form the static backdrop to the national "project" and his book is deliberately titled *The Empire Project* to undermine this tendency.[4] A narrative on American ecology might look at the intellectual traditions established by George Perkins Marsh or Frederic Clements and de-emphasize how much they relied on German scientific writers. A story of European life science might remember how Hugo de Vries or Karl Tschernak re-discovered Mendel in 1900 but forget that William Jasper Spillman did the same in Oregon around the same time. It is, of course, equally true that any historical narrative will inevitably tell one partial truth and leave out a great deal. A history on the rise of ecology as a discipline could demote the masses of specimens donated to herbariums and museums by enthusiastic amateurs. Nevertheless, nationalist histories of science *always* distort the truth because scientific practice has always been an international endeavor. The most effective scientific networks should cross all social boundaries, whether those boundaries were nations or were factors of class, race or gender. The individuals involved fully realized that knowledge was the outcome of relationships.

---

2 Patrick Manning, *Navigating World History: Historians Create a Global Past* (New York: Palgrave Macmillan, 2003), 3.

3 Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science, 1848-60* (Urbana: University of Illinois Press, 1976), 2.

4 John Darwin, *The Empire Project: The Rise and Fall of the British World-System, 1830-1970* (Cambridge, United Kingdom: Cambridge University Press, 2009), 7.

Overview of the Study

Environmental sociologists John Bellamy Foster and Brett Clark recently took a well-known, often quoted comment from Welsh academic and novelist Raymond Henry Williams on nature and turned it on its head. Williams claimed that nature contains "an extraordinary amount of human history" but Foster and Clark asserted that the "idea of society is often erected on conceptions of nature."[5] Ecology is at present understood to be the branch of biology dealing with the relations of organisms to one another and their physical surroundings, while the sub-field of human ecology focuses on the interaction of people with their environment. The discipline of ecology was initially proposed in the 1860s, and the first studies were rooted in the work and perspective of English naturalist Charles Darwin. Darwin's thesis on natural selection is famous for inspiring a host of theories regarding the struggle between life forms, and even more analogies between his vision of a highly competitive natural world and certain perceived similarities witnessed in the economic and social atmosphere of Victorian society. Present-day ecologists are often sharply critical of capitalism and *laissez-faire* economics. At first glance, the perspective of Darwinists seems to be diametrically opposite, but contemporary ecology is a direct descendant of Darwin's investigations into the so-called "species question." The achievements of the biologists and ecologists of the early twentieth century rest quite firmly in the early nineteenth century, with pioneering field work conducted by talented amateurs and gentleman scholars.[6]

This examination focuses on science as a social activity. I cannot claim specific training in the sciences, and the intellectual history of ecology has previously been thoroughly discussed by several leading historians. Three foundational monographs from the history of science that I have relied upon for chronological descriptions of ecological concepts include Ernst Mayr's *The Growth of Biological Thought*, Peter Bowler and Iain Morus's *Making Modern Science*, and Robert McIntosh's *The Background of Ecology*.[7] Social histories of ecology began with Donald Worster's *Nature's Economy*, originally published in 1977, but studies specifically analyzing ecology networks are quite recent. Foremost among these are Raf De Bont's work on marine

5 John Bellamy Foster and Brett Clark, "The Sociology of Ecology," *Organization & Environment* 21, no. 3 (2008).

6 As historian Gregory Cooper has recalled, ecology was defined as "scientific natural history" as late as 1927. Cooper was citing English scientist Charles Elton's definition. See Gregory John Cooper, *The Science of the Struggle for Existence: On the Foundations of Ecology* (Cambridge, United Kingdom: Cambridge University Press, 2003), 30-1.

7 Ernst Mayr, *The Growth of Biological Thought: Diversity, Evolution, and Inheritance* (Cambridge, Mass.: Belknap Press, 2003); Peter J. Bowler and Iwan Rhys Morus, *Making Modern Science: A Historical Survey* (Chicago: University of Chicago Press, 2005); Robert McIntosh, *The Background of Ecology: Concept and Theory* (Cambridge, United Kingdom: Cambridge University Press, 1985).

stations in France and Belgium and Colin Riordan's examination of green thinking in Germany.[8] My study contributes to this latter line of inquiry, although I argue for an expansive approach that considers ecology to be one large international network, based on a reconstruction of personal connections and supported by commentary from the participants themselves. In terms of primary sources, I have been spoiled for choice, but the main source is the proceedings of the International Congress of Arts and Science, supplemented by the official history of the Louisiana Purchase Exposition by Mark Bennitt, and material from the British Foreign Office located at the National Archives at Kew, London.[9]

The discussion here emphasizes that the network was created by interested individuals in spite of physical, social, and intellectual obstacles. Intellectual obstacles were often the most difficult to overcome. Widespread preference in universities was for laboratory research, while the emphasis for ecologists has always been on field studies. In the latter decades of the nineteenth century, any biologists who worked in the field struggled to maintain respectability in a discipline that was seeking to distance itself from its roots in the practice of natural history. At the ICAS, those scientists found themselves vulnerable to criticism from their peers in the hard sciences. The split between field and lab to some extent reinforced a chasm that had developed between loyal Darwinists and Lamarckians, a difference of opinion that would eventually resolve itself with the reconciliation between Mendelian genetics and natural selection (labeled "the modern evolutionary synthesis" by Julian Huxley in 1942).[10] It was a glaring point of departure, however, for some of the participants.

North American scientists had to overcome a social hierarchy in science that was partly derived from physical distance. At the ICAS, they were eager to prove to their European counterparts that their research and institutions had advanced to the point of being on par with

---

8 Raf De Bont, *Stations in the Field: A History of Place-Based Animal Research, 1870-1930* (Chicago: Chicago University Press, 2015); Colin Riordan, *Green Thought in German Culture: Historical and Contemporary Perspectives* (Cardiff: University of Wales, 1997); Donald Worster, *Nature's Economy: A History of Ecological Ideas* (Cambridge, United Kingdom: Cambridge University Press, 1985).

9 Howard Jason Rogers (Ed.) *International Congress of Arts and Science*, 13 vols. London and New York, University Alliance, 1908; Mark Bennitt, with photographs edited by Frank Parker Stockbridge. *History of the Louisiana Purchase Exposition, Comprising the History of the Louisiana Territory, the Story of the Louisiana Purchase and a Full Account of the Great Exposition, Embracing the Participation of the States and Nations of the World, and Other Events of the St. Louis World's Fair of 1904*. Saint Louis: Universal Exposition Publishing Company, 1905.

10 Between 1936 and 1947, biologists came to agree that, firstly, evolution is gradual and brought about by small genetic changes, and, secondly, the origin of higher taxa can be explained by analyzed the effects of environmental factors (including niche occupation and competition) on isolated, reproducing populations. By studying genetic diversity and the origin of higher taxa with this new perspective, ecologist could then explain all evolutionary phenomena in a way that was consistent with previous study. For a complete technical discussion, see Mayr, *The Growth of Biological Thought*, 566-70.

the great institutions of learning—the same institutions that many of them had necessarily made pilgrimages to in their youth in order to complete their education. For this reason, the LPE has occasionally been compared to a débutante ball where the North American academy revealed they had come of age.[11] Hosting the Congress at the LPE was a major effort. It was led by a committee of university academics and administrators who were forced to overcome initial resistance from English diplomats due to "fair fatigue" in the wake of the great exhibition in Paris, 1900. They then had to convince the scientists themselves to leave their comfortable situations in England, France, and Germany to travel by sea and then train to the Western United States of America to speak at a world fair that would be largely populated by social inferiors. The strategy and salesmanship that were required to achieve such spectacular results are the subject of Chapter Two.

It is evident that scientific developments across the Atlantic were often geographically isolated but rarely intellectually isolated from one another. A visit from Alexander von Humboldt to President Thomas Jefferson in 1803 (the same week the Corps of Discovery expedition into the Missouri River region was launched) has been identified as a key event in the history of ecology by historian Aaron Sachs.[12] Chapter Three discusses how that visit coincidentally reinforces the same period that Hugo Münsterberg, the lead organizer of the ICAS, asked speakers to reflect upon. Münsterberg had asked the speakers to discuss the development of their fields since 1803 because the Exposition celebrated the centenary of the Louisiana Purchase. In fact, coincidences, tangential connections, and unintentional influences on outcomes are often essential to understanding how networks functioned. Forays of Americans to Europe in pursuit of knowledge began around the same time as the visit between Humboldt and Jefferson. In 1805, a group of leading citizens funded the Massachusetts Professorship in Natural Botany at Harvard. The first and only appointment was William Dandridge Peck, who immediately toured Europe to prepare for his position.[13] He was an early pioneer in what became a long-term trend, where aspiring academics made a trip to Europe to study collections, make connections, and be brought up to date in the latest theories—it was akin to a finishing school for scientists. Peck would go on to teach a number of subjects in natural history and establish a botanic garden on university grounds. The initial cross-Atlantic connections made during Humboldt's generation were expanded and intensified in the middle of the nineteenth century, and debates erupted regarding nomenclature of species, and evolution of species on both sides of the Atlantic.

Chapter Four discusses how English naturalist Charles Darwin and his circle of investigators

---

11 A. W. Coats, "American Scholarship Comes of Age: The Louisiana Purchase Exposition 1904," *Journal of the History of Ideas* 22, no. 3 (1961).

12 Aaron Sachs, *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism* (London: Penguin Books, 2007).

13 A. Hunter Dupree, *Asa Gray, 1810-1888* (Cambridge, United Kingdom: Belknap Press, 1959), 104.

cast long shadows in the world of plant ecology. A key member of the early network on the American side of the Atlantic was Harvard botanist Asa Gray, inheritor of Peck's garden. A lecture on "The Problems of Ecology" at the ICAS was provided by his direct intellectual descendant, Benjamin Lincoln Robinson, the Asa Gray Professor of Systematic Botany at Harvard University.[14] Robinson is a typical example of a young, bright American who began post-secondary studies in America and then went to Europe to finish his education. He obtained his first degree from Harvard in 1887, and obtained a PhD through Strasbourg. When he appeared at the ICAS, Robinson had been curator of the herbarium that Gray established for more than a decade, and he was involved in editing Gray's scientific volumes and improving the physical housing of specimens in its collection. He had also published a reference volume on the Galapagos Islands, based on the Hopkins-Standford Expedition which retraced Charles Darwin's steps in the region.[15]

In the section on ecology at the Congress, Robinson presented with German phytogeographer Oscar Drude, curator of the Dresden botanical garden. Both men spoke on the development of their field, tying the rise of scientific ecology to the publication of Darwin's *Origin of the Species* and to additional field work conducted by life scientists during the nineteenth century. Drude argued that ecological thinking extended farther back into the eighteenth century, when Swedish botanist Carl von Linné (a.k.a Linnaeus) and German naturalist Alexander von Humboldt established the basic methodology and terminology for botany. He contended that each scientist initiated a "phase" in the development of ecology. Drude described the third phase as the era when "Darwin's great intellectual achievements bore universal fruit."[16] Robinson similarly acknowledged the towering role of Darwin.[17] Drude and Robinson were effectively the inheritors of this rich intellectual legacy but were creatures of a different era: they would be considered part of the fourth and fifth phases of ecology that Drude provided in his schematic.[18] The speakers had spent their entire careers working as professional scientists, navigating a complex web of amateur, professional, and practical interests. Chapter Five discusses the intellectual landscape of the fifth generation, which considered

---

14 Benjamin Lincoln Robinson, "The Problems of Ecology." *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908. See also Fernald, Merritt L. "Benjamin Lincoln Robinson (1864-1935)." *Proceedings of the American Academy of Arts and Sciences* 71, no. 10 (1937): 539-43.

15 Fernald, Merritt L. *Biographical Memoir of Benjamin Lincoln Robinson (1864-1935)*. National Academy of Sciences (Washington, DC, 1936): 310. See also Archives of the Gray Herbarium, Harvard University Herbaria. *Papers of Benjamin Lincoln Robinson, 1887-1934: A Guide* (Harvard University: 1999). Available online at: http://oasis.lib.harvard.edu/oasis/deliver/~gra00046

16 Oscar Drude, "The Position of Ecology in Modern Science." *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908), 181.

17 Robinson, "The Problems of Ecology," 194.

18 Drude discusses the fourth and fifth stage of ecology in "The Position of Ecology in Modern Science," pp. 182-3.

itself new, professional, and modern. The fifth generation was not fully cognizant, however, of how the practice of history and ecology were interconnected, and how that interdisciplinary trend would accelerate in the twentieth century. This aspect of the early ecology network is addressed in Chapter Six, followed by some concluding thoughts on the impact and legacy of the Congress.

The Social Network Diagram

The appendices contain additional information concerning the social relationships between the early ecologists discussed in this dissertation. Appendix A provides a list of the participants in the ICAS along with the institutions they represented. Appendix B provides a social network diagram based on information in the proceedings about relationships between those participants in the ICAS interested in ecology, supplemented with details from National Academy of Science memoirs. The intention is to visualize the connections between this self-selected group of attendees and important influences on their careers—it is not a complete diagram of all early ecologists.

This dissertation is a social history, and the diagram similarly prioritizes social relationships rather than publications of ecologists. I am not suggesting that publications are not vitally important to the history of scientific disciplines, but rather employing an approach that includes contributors that may otherwise be overlooked: wives, assistants, informal mentors, and amateur collectors, for example. To create the diagram, sections of the proceedings that contained ecological information were first identified, and the pages were prepared using the Optical Character Recognition process from Adobe Acrobat Professional. Major keywords and names were identified and analyzed, for example discovering how often the name "Darwin" was mentioned. In the proceedings, a short curriculum vitae was provided before each lecture, and the biographical details the publishers provided became the basis for identifying professional relationships. Relationship categories were established, moving from most to least pertinent to the ecology network: mentors, employers, friends, colleagues, correspondents, relatives, and influences. Mentors were typically graduate school advisors, but could also include informal mentorships, such as when Alexander von Humboldt decided to introduce Louis Agassiz to scientific society. Employers were usually laboratory supervisors or museum directors with direct hiring power. Friends were two of the network members who socialized outside of work spaces, or individuals that connected two network members but were not biologists themselves. Colleagues worked in the same departments or were known to associated with each other in the course of performing their duties (curators that regularly traded specimens or worked on commitees, for example). Relatives were family members that also worked in the same laboratories or published together, for example Frederic Clements and his wife, Edith. Influences were indirect connections, such as the influence Alexander von Humboldt had on Franz Boas—the two men never met, but Boas was known to keep a bust of Humboldt by his bedside. The only purpose of ranking the reltationships was to eliminate multiple

connections between two people. It is more important to the social network that Joseph Dalton Hooker and Charles Darwin were friends than that they corresponded with one another. Therefore they are identified as friends in the diagram. Finally, several notable cases of antipathy were also included in the diagram. This category was added to accomodate cases like Asa Gray and Louis Agassiz, two individuals that were undeniably connected, but disliked one another intensely.

The names of individuals identified were inputted to a spreadsheet, which became a list of nodes, and the relationships identified became a worksheet filled with edges. The nodes and edges were imported into Gephi, a free, open-source software program that creates graphs and diagrams. Gephi algorithms first randomized the edges, then centralized those nodes that had more edges. Heat mapping was applied, so that the more well-connected nodes showed as red. The least connected individuals around the periphery were eliminated. Finally, the diagram was rounded out into a circular shape to improve viewability. The result is a diagram showing known, interconnected individuals that attended ICAS 1904 and showed evidence of ecological thinking, within their social framework.

Historiography

A main feature, and shortcoming, of the academic study of ecology is the quagmire produced by numerous attempts to separate scientific ecology from political ecology, conservationism, and environmental history. While an overview of this historiography may be philosophically stimulating, most attempts at definition tend to be quite confusing to the non-scientist. In her examination of the history of ecology, historian Anna Bramwell was inclined to sweep these distinctions away, and her approach may be controversial, but sane.[19] A more approachable tactic is to look at ecology as a social network; this approach is already a major component of several new histories of ecology published during the last decade, including the work of Raf De Bont and Aaron Sachs. The networking approach provides the theoretical basis for this study, which investigates the social and intellectual connections between a subset of the speakers who participated in the ICAS in St. Louis, 1904. Because the speakers are treated as experts on the discipline and the professional network, their own backgrounds and the structure of the Congress itself require interrogation. Therefore an analysis of the physical layout, participation, and intellectual content at St. Louis is given nearly equal weight to the examination of ecology itself.

A colloquial description of taxonomists points to the tendency of some osbervers to group varieties of organisms together into larger and more diverse species (the “lumpers”), whereas others create individual species for more variants (the “splitters”). Historians can also be lumpers and splitters. Not being a “splitter” by nature, I prefer to avoid classifying ecologists and instead rely on historian Martin J.S. Rudwick’s social framework for science, which depicts scientific

19 Anna Bramwell, *Ecology in the 20th Century: A History*. New Haven: Yale University Press, 1989.

progress as an ongoing production in the theatrical rather than the industrial sense, featuring a cast of characters that includes leading roles as well as "minor actors and walk on parts."[20] More to the point, Raf De Bont has described early ecology as constituting several competing networks of scientists.[21] This study will build on these proposals, but contends that ecology was one large social network with different clusters being unevenly integrated. If ecology is presented as a network with a specific historical context, rather than a discipline that "evolved" over time, it is understandable that scientific ecology can be affected by politics, and that ecology associated with "green politics" can be informed by science. Both traditions have intellectual roots that reach back over two centuries.

Early Ecology in Retrospect

Ecology in the twenty-first century is defined as the branch of biology that deals with the relationships of organisms to one another and to their physical surroundings. In a secondary definition, ecology can refer to a political movement concerned with the protection of the environment. These dual definitions pervade the field and frustrate historians interested in the history of ecology. Historical tracts have tended to qualify whether the author was examining "scientific ecology," "ecological thinking," or "modern ecology," with the latter being a particularly unclear concept that seems to lean towards either ethically informed scientific treatises, or scientifically informed ethical treatises. Within the history of science, distinguishing between the two kinds of ecology has been attempted by a handful of academics, but the two remain like conjoined twins.

Historians interested in scientific ecology often attempted "Great Man" history, looking for personalities that influenced or established a discipline. Donald Worster, who argued that present-day ecologists are seen as prophets and therefore should be debunked for cultural bias, understandably begins his narrative with eighteenth-century natural theologians.[22] In his history of ecology, *The Balance of Nature*, John Kircher placed the separate discovery of natural selection

20 Martin J.S. Rudwick, *The Great Devonian Controversy: The Shaping of Scientific Knowledge among Gentlemanly Specialists* (Chicago: The University of Chicago Press, 1988).

21 Raf De Bont, "Organisms in Their Milieu: Alfred Giard, His Pupils, and Early Ethology, 1870-1930." *Isis* 101, no. 1 (2010).

22 Worster, *Nature's Economy*, 344. Natural theology sought to prove the existence of God through evidence in nature. It was initially called "physico-theology" by seventeenth-century ornithologist John Ray. For further discussion, see Tim Birkhead's *The Wisdom of Birds: An Illustrated History of Ornithology* (London: Bloomsbury, 2008), 7-8.

by English naturalists Charles Darwin and Alfred Russel Wallace as fundamental to ecology.[23] Kricher argued that Darwin in particular demonstrated that survival and success in reproduction are not random in nature, and that natural selection was a mechanism that was not prescient. Natural selection concerned organisms and adaptation to existing conditions, and as such, Kricher considered Darwin's *The Origin of the Species* to be "the first decent ecology text."[24] Kricher's approach was to look for evidence of ecological thinking and he found it in abundance in Darwin. In contrast, historians Peter J. Bowler and Iwan Rhys Morus argue in *Making Modern Science* that ecology was a distinct field of study that emerged only at the end of the nineteenth century, although concepts now associated with the discipline such as natural selection had long been recognized.[25] In their view, Darwin contributed concepts but was not a direct part of scientific ecology. Bowler and Morus found that ecology arose out of the "breakdown of the descriptive or morphological approach to nature" when a new emphasis was placed on experimentation, using physiology as the model.[26] They claimed that only then did a number of new biological disciplines, including ecology and genetics, appear. Bowler and Morus' interest in professionalization led them to see something new and different in ecology occurring at the turn of the twentieth century, and their favoured innovator was Eugenius Warming. None of these works, however, gave much credit to the German biologist who provided the term ecology, Ernst Haeckel, champion of Darwin.

The bare facts regarding Haeckel and the discipline of ecology are straightforward. Most scholarship dates ecology from 1866, because that is when Haeckel coined the term *oecology* and inadvertently established a new field in science. He did not develop the idea into a discipline, and the word did not come into general usage for many years. From there, the opinions diverge. Bowler and Morus discussed how the term, derived from the Greek word *oikos*, referred to the operations of the family household. The *oecology* of a region would demonstrate how the species there interacted to exploit its natural resources.[27] Historian Sharon Kingsland argued that Haeckel

23 Kricher, *The Balance of Nature*, 52-55. Kricher argued that overcoming the paradigm of the balance of nature was key to the development of ecology, and Wallace and Darwin contributed to that process. Wallace observed that every species had come into existence coincident in both space and time with a closied allied species. Darwin's theory of natural selection provided a mechanism for evolution. Organisms that possess favourable traits enabling them to cope or compete (with predators or climate, for example) tend to survive. They reproduce and pass these traits on to subsequent generations, thereby preserving the preservation of the traits in the population. See Wallace, "On the Law which has Regulated the Introduction of Species." *Annals of the Magazine of Natural History Series 2* Vol 16, No. 93 (1855): 184-196; Charles Darwin, *On the Origin of Species by Means of Natural Selection: Or, the Preservation of Favoured Races in the Struggle for Life* (London: John Murray, 1859)

24 Kricher, *The Balance of Nature*, 63.

25 Bowler and Morus, *Making Modern Science*, 223.

26 *Ibid.*

27 *Ibid*., 222.

was merely indicating a set of problems suggested by Darwin's "struggle for existence" that needed further study.[28] In *The Science of the Struggle for Existence*, historian Gregory Cooper chose an approach that arose out of his concern that "foundational controversies involve, sooner or later, questions of disciplinary identity" and opted to "defend a particular definition of ecology."[29] For him, Haeckel originally defined ecology as the science that studies what Darwin had called the struggle for existence. Cooper, Bowler, Morus and Kingsland all used Haeckel's definition as a useful signpost to begin a discussion, but were essentially dismissive of his role as a scientist. Haeckel, however, not only named the field but provided a unique model as a politically-oriented scientist.

In his biography of Haeckel, historian Robert J. Richard placed the German biologists' contributions within their context. Haeckel was part of a culture influenced by high Romanticism and a type of enlightened science, the mixture of which produced an era that "rippled with individuals of out-sized talents."[30] In Richards' view, Haeckel was one of these talents, and much of Haeckel's publications bore the influence of his artistic, mercurial personality and his German scientific training. Richards described how in 1864 Haeckel sent Darwin two folio volumes on radiolarians, defined as a group of one-celled marine organisms that contained skeletons of silica having unusual geometries. Darwin was astonished by the beauty of the scientific art, and was also drawn to passages that applied his own theories to construct the descent relations of these little-known creatures.[31] Soon after, Darwin was forwarded an article from a German newspaper that described a meeting of the Society of German Natural Scientists and Physicians at Stettin, where Haeckel defended Darwin in a lecture. Haeckel would become "the foremost champion of Darwinism not only in Germany but throughout the world."[32] Richards argued that before the outbreak of the World War in 1914, it was through the works of Haeckel that most lay people were first introduced to Darwin's theories.[33] Through those lavishly illustrated, voluminous publications, the scientifically inclined public could place evolutionary ideas in a broader philosophical and social context. Today, his propagation of the biogenetic law, where the development of embryos supposedly mirrored phylogeny, is correctly maligned. A place for him in the history of science remains because of his work on *Prostista* and his provision of the term *oekologie*, which he

28 Sharon Kingsland, *The Evolution of American Ecology, 1890-2000* (Baltimore: Johns Hopkins University Press, 2005), 2.

29 Cooper, *The Science of the Struggle for Existence*, 1. See pp 1-6 for the discussion on philosophy.

30 Robert J. Richards, *The Tragic Sense of Life: Ernst Haeckel and the Struggle over Evolutionary Thought* (Chicago: University of Chicago, 2008), xvii.

31 *Ibid.*

32 *Ibid.*, 2.

33 *Ibid.*

considered to be "the entire science of the relationships of the organism to its surrounding external world, wherein we understand all 'existence-relationships' in the wider sense."[34] Haeckel did not have the influence to single-handedly establish a new scientific discipline, but Richards asserted that "Haeckel understood the fundamental message of Darwin: that creatures lived entangled in a large network of connections to the inorganic and organic environments."[35] Richards has improved our understanding of the relationship between Haeckel and Darwin as individuals, and supports the argument that Haeckel was an ecological thinker, if not an actual ecologist.

Historian Colin Riordan similarly argued that the scientific basis for ecologism, the political form of ecology, was formulated by Haeckel, although he does not provide a detailed examination of his scientific contributions.[36] But Haeckel's defenders are few, and his detractors have argued that Haeckel was inspired by Darwin but not "really" a Darwinist. Bowler and Morus emphasized that there remains a wide division between the concepts that Darwin and Haeckel put forward: most notably, Darwin was usually considered a materialist, while Haeckel adopted a non-materialistic view of nature where living things were active agents within a unified and progressive world.[37] Bowler, Morus and Riordan suggested that, even at an early stage, a tension existed between materialistic and holistic world-view in ecological thinking. No consensus has emerged on these ideas within the history of science, nor should there be: ecologists themselves can be essentially Romantics by disposition. Haeckel was a supporter of Darwin, and he provided a scientific definition for ecology, but he has also been characterized as one of the great Romantics. Bramwell claimed that Haeckel's work provided an anti-mechanistic and holistic approach for biology.[38] She also identified a second strand of ecologism that arose in the late nineteenth century, one that resembled energy economics, which focused on issues related to scarcity and non-renewable resources.[39] She argued that the two categories had a certain amount of cross-membership and they "fused" much later in the 1970s, but the economic emphasis took precedence at first because the biologically-based ecological movement lost credibility due to its links with Germany.[40] Bramwell was vociferous about this aspect of the history of ecology: she saw ecology as essentially political, but possessing a scientific component and an environmental variant. She also emphasized that

34 *Ibid*., 8 (footnote 28).

35 *Ibid*., 144.

36 Colin Riordan, *Green Thought in German Culture: Historical and Contemporary Perspectives* (Cardiff: University of Wales, 1997), 7.

37 Bowler and Morus, *Making Modern Science*, 222.

38 Anna Bramwell, *Ecology in the 20th Century: A History* (New Haven: Yale University, 1989), 4.

39 *Ibid*.

40 *Ibid*.

ecological thinking has always been most prominent in Britain, Germany, and North America, and today the same countries host the most mobilized environmental groups.[41] Haeckel was presented as a political figure although "his reforms sprang directly from his scientific belief.[42] His love of nature and advocation for pantheism was evident in his published works, which were translated and had a mass distribution in English-speaking countries. Bramwell demonstrated that Haeckel's influence among self-educated working men was enormous, on par with Darwin and Marx, and his link with ecology was not limited to inventing the term.[43] Rather, both his politics and his scientific work touched upon concerns fundamental to ecology today.[44] Along with her rejection of any bifurcation of scientific ecology and political ecology, Bramwell also brought to the forefront German content: almost a third of her book concerned German interpretation of ecology.[45] She supported her argument with discussions that are endemic to the history of ecology such as the relationship between humans and nature, the influence of an aesthetic ideal in nature, and the close alliance between understanding nature and managing nature. Bramwell's conclusion was that politics and ecology cannot be separated. The discussion here largely supports Bramwell's claims, with one caution: whatever they may have privately thought, early ecological thinkers did not often talk about environmental politics or conservation in their official capacity as academics, even at a politically-oriented event like the ICAS. Ecologists today are regularly involved in impact assessments and risk analysis, which assumes an ethical component.

Many ecologists and environmentalists publishing at the new millennium are convinced that ecological issues are a relatively new concern. According to Bowler and Morus, however, the early environmentalist movement can be found within the Romantic thinkers of the early nineteenth century who conceived of the wilderness as a source of "spiritual renewal" and expressed hatred towards industrialists who destroyed it for profit.[46] In the same manner, Donald Worster began his social history of ecology by first describing the Arcadian tradition and then associating it with Romanticism, conservationism, vitalism, and holism. He perceived those concepts as aggregating

41 *Ibid*., 5.

42 *Ibid*., 40. Bramwell also provides an overview of the arguments of HL Parsons and Marcel Prenant, who have hailed Karl Marx as the first ecologist due to his arguments against the exploitation of people and land under capitalism. Prenant quotes Marx in *The German Ideology* saying "As long as men exist the history of Nature and the history of men mutually determine each other." But she concludes that Parsons and Prenant are going too far – she sees ecologists as not being anthropocentric, whereas Marx was anthropocentric, his progressive ideal rested on Lewis Morgan's stadial theory of civilization, and he thought of primitive tribes as barbarous, not admirable.

43 *Ibid*., 41.

44 *Ibid*., 53.

45 *Ibid*., 10. She credits geographer David Popper with providing the same kind of profile for English ecology, and Donald Worster for covering the American story.

46 Bowler and Morus, *Making Modern Science*, 218.

over time, ultimately constituting a theme that reappears throughout the twentieth century, typically as a platform to argue against the dominance of science and technology. He identified the large-scale impact American marine biologist Rachel Carson made when she published *Silent Spring* in 1962, citing the public furor she instigated as an example of the Romantic tradition finally being fulfilled. Worster wrote that Carson's book "marshaled substantial scientific evidence of the threat to life posed by persistent pesticides" and inaugurated "the literature of ecological collapse."[47] In her book Carson referred to nineteenth century biologists as existing in a Neanderthal state. It is important to recognize that when she released *Silent Spring* she was already arguing against a long established discipline, one that possessed a recognizable lexicon and featured a body of standard works. The field of ecology was already populated with practicing specialists trained in the field and demonstrably well-versed its history, although as Carson noted their advice was rarely heeded.[48]

Ecology can be understood both in terms of its content, which discusses nature and in particular the organism and its environment, but also as a culture of inquiry that involved, produced, and rejected people who demonstrated interest in ecological thinking. Carson has been depicted as an outsider, primarily designated so by her gender but also because she was a marine biologist, a government employee possessing an MA rather than a PhD, and someone who had previously authored books aimed at the public.[49] She, for her part, addressed the existence of ecology as a field by sharply criticizing it as being exclusive and ineffectual. She had embedded an ethical perspective into her science. Her narrative directly implored the public to place checks upon excesses taken in the agricultural industry and shortcomings in scientific ecology as a discipline, attempting to wedge the two apart in the interests of protecting future generations.

Carson's darkly toned commentary, variously described as whistle-blowing, apocalyptic, anti-industrialist, or even histrionic, had an important role in raising awareness about ecological issues.[50] It also opened the way for several generations of environmentally-focused journalists. The United Nations Conference on Environment and Development 1992 ("Rio 1992") brought a new level of international attention to environmentalist issues: thereafter, journalists and non-governmental organizations provided a steady stream of information emphasizing the urgency of reducing greenhouse gas emissions (GHGs) and mitigating the effects of the warming climate.

---

47 Worster, *Nature's Economy*, 23.

48 Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin ebooks, 2002), 47.8.

49 See Linda J. Lear, *Rachel Carson: Witness for Nature* (New York: H. Holt, 1997), 30. See also Jean Langenheim, "Early History and Progress of Women Ecologists." *Annual Review of Ecology and Systematics* 27 (1996): 1-53.

50 Linda J. Lear, "Rachel Carson's 'Silent Spring'," *Environmental History Review* 17, no. 2 (1993). For a discussion of the reaction of ecologists to Carson, see William Dritschilo, "Rachel Carson and Mid-Twentieth Century Ecology." *Bulletin of the Ecological Society of America* 87, no. 4 (2006): 357-67.

Yet historian Aaron Sachs remarked that his own interest in early ecology grew out of his disillusionment as an environmental writer in the 1990s.[51] He recalled how international concern with anthropogenic deterioration of the environment had developed into a pressing political issue and argued that the 1990s were the decade where thinking "green" reached its peak. Sachs found the standard gloomy, catastrophe-obsessed rhetoric to be unsatisfactory and frustrating. When he "tired of forecasting ecological doom," he set out to mine the past "for a sense of intellectual continuity and for potentially useful ideas that might have been consigned to history's dust bin."[52] Historical studies published in the last decade, like that of Sachs and also the work of Colin Riordan, do not necessarily see holism as a new trend. In *Green Thought in German Culture*, Riordan purported that holism was, and is, a universal concept. Like Worster and Sachs, he found continuity from natural histories of the eighteenth century to the science of the contemporary ecologist.[53]

Literature professor Robert Pogue Harrison has mused that "whatever the rift that separates their regimes, nature and culture have at least this much in common: both compel the living to serve the interests of the unborn."[54] He went on to differentiate between the two: whereas culture perpetuates itself through the power of the dead, nature makes no use of this resource except in the strictly organic sense. He claims the dead and the unborn are therefore "native allies, so much so that from their posthumous abode—wherever it may be—the former hound the living with guilt, dread, and sense of responsibility, obliging us, by whatever means necessary, to take the unborn into our care and to keep the story going, even if we never quite figure out what the story is about…" From the perspective of contemporary environmental activists, the early twentieth century may seem intellectually remote.[55] Yet today's ecologists and conservationists may benefit from arguing that their position is part of Western heritage rather than assuming they operate as outsiders. For those curious few interested in their ecological roots, there are numerous personalities to borrow and learn from: factotums, collectors, intellectual dissenters, guardians of herbariums, scientific illustrators, romantic philosophers, teachers and mavericks. Each individual was involved in their own epharmony, coping with their limitations and struggling to survive, but they nevertheless contributed to the whole.

The linkages between the individuals involved in early ecology vary in type and intensity. Sometimes the relationships are obvious, such as when two colleagues worked and published

51 Sachs, *The Humboldt Current*, 12.

52 *Ibid*.

53 Riordan, 4-8.

54 Robert Pogue Harrison, *The Dominion of the Dead* (Chicago: University of Chicago Press, 2003), ix.

55 Daniel Bodansky, "Prologue to the Climate Change Convention," in *Negotiating Climate Change: The Inside Story of the Rio Convention*, ed. Irving M. Mintzer and J. Amber Leonard (Cambridge, UK: Cambridge University Press, 1994), 46.

together, or when one biologist trained a dozen graduate students in a particular specialization. Sometimes the connections are layered, for example when two individuals are related to one another and also publish together as colleagues within a profession. Other times the relationship is not immediately apparent, as occurred when wives of scientists contributed as editors, illustrators, and laboratory assistants but were not paid or otherwise credited. There is also the effect of antipathy to consider. Rivalries and mutual antipathy were an important type of relationship in professional science, but are more difficult to analyze for impact upon the development of the discipline. By mapping the connections between the participants at the ICAS, it is possible to begin with one known type of relationship that can be readily confirmed and is a complete set of relationships. Using the ICAS connections as a base, it is then possible to build outwards from those known connections and form a more complete picture of how ecological knowledge was transmitted in the earliest phases of the discipline. By restricting the analysis to the proceedings, this dissertation focuses on a particular, self-selected collection of individuals associated with early ecology. Certain lesser-known individuals and groups that contributed to the discipline are identified, and the many transatlantic connections are emphasized. This approach cannot address intellectual milestones in the development of the discipline or the important role that publishing plays in every academic field. It does, however, offer a glimpse into how ecologists viewed themselves and the field at the beginning of the twentieth century, in their own words.

CHAPTER TWO

THE ACCIDENTAL SURVEY

Members of the Smithsonian Institution constructed a birdcage for the Louisiana Purchase Exposition (LPE) in St. Louis, 1904. It was no ordinary birdcage, but rather an enormous public aviary, a flight cage truly extraordinary in size and ambitious in scope. One of only two remaining permanent structures built for that World's Fair, it was constructed of steel ribs and wire mesh resting on a wooden base. Erected in Forest Park and measuring 228 feet long, 84 feet wide, and 50 feet high, the aviary was at the time the largest birdcage ever constructed. Visitors walked through via a screen-covered arcade and witnessed exotic and native birds mingling together in flight. The Smithsonian initially intended to dismantle it at the conclusion of the Fair and move it to Washington, DC but St. Louis had the legal authority to retain the structure and instead opted to make it the basis for a new zoo. Built for $17,500, the city acquired it for $3,500. This bargain has long been identified as "one of the premier treasures of the St. Louis"[1] and today, it houses the Cypress Swamp exhibit which teaches visitors about avian ecology in the local ecosystem.

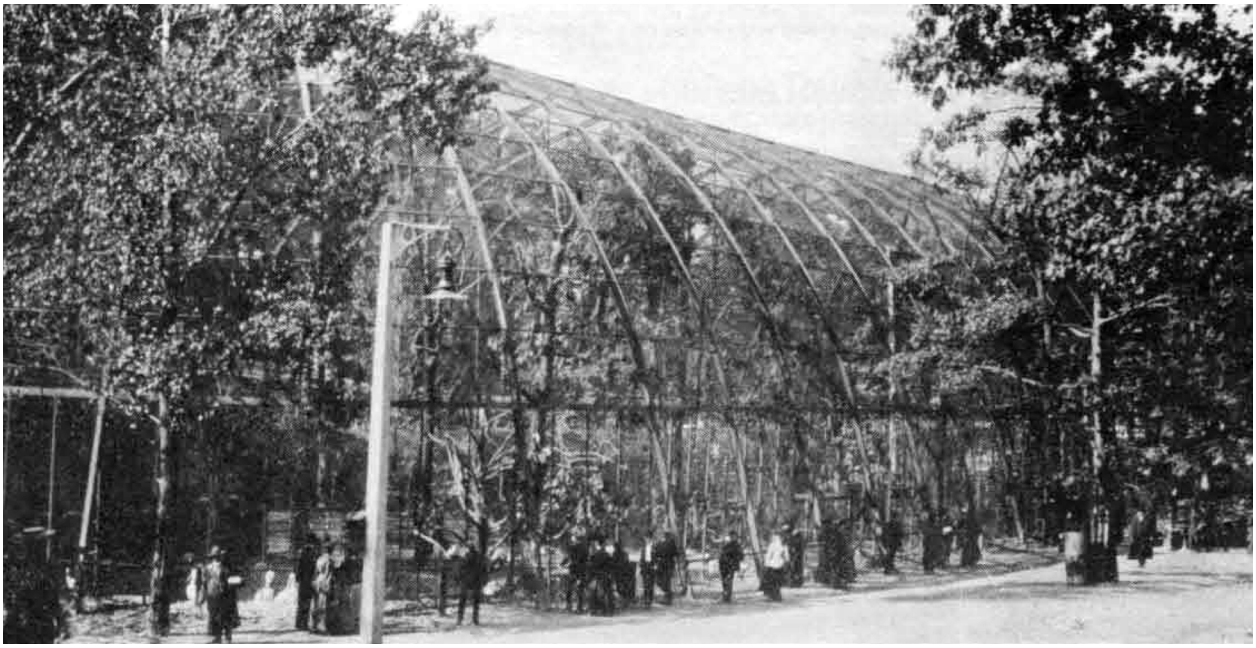

Figure 2.1. The aviary at the Louisiana Purchase Exposition, 1904.[2]

1 Diane Rademacher, *Still Shining: Discovering Lost Treasures from the 1904 St. Louis World's Fair* (St. Louis: Virginia, 2003), 48.

2 "The Largest Birdcage ever Built, Containing the Exhibit of the National Zoological Park." From Mark Bennitt, *History of the Louisiana Purchase Exposition* (St. Louis: Universal Exposition Publishing Company, 1905), 339. Photograph by William H. Rau. Public Domain.

In the center of the fairgrounds, another kind of birdcage was constructed—namely, Festival Hall. Festival Hall was also envisioned as a short-lived but eye-catching structure. It was 145 feet wide and set on a cylindrical base 200 feet wide, sporting a crested dome and an interior capable of seating 4000 guests, along with a stage that could support a full orchestra. In front of the Hall were elaborate fountains lined with colonnades that descended into a lagoon. The three cascades poured out 90,000 gallons a minute. Festival Hall hosted much of the feature entertainment during that Fair, as well as a number of conventions and conferences held on the fairgrounds. In September, it served as a main venue for the International Congress of Arts and Science (ICAS), when another variation of species was put on display for the public: over 400 exotic and native academics, mingling at will and giving speeches on their latest research.

Figure 2.2. Festival Hall, 1904.[3]

3 David Coleman, "Festival Hall", Digital Collections, University Libraries, University of Maryland. Available online at: http://digital.lib.umd.edu/worldsfairs/record?pid=umd:751. Fair use for research provided.

The ICAS is significant to the history of ecology because it was the first major academic conference that recognized ecology as a field in its own right. It is important that this acknowledgment occurred at a universal exposition held in western North America. The history of ecology is often bifurcated into a European narrative and an American one, with the scientists of the British colonies sometimes being included with the motherland or with their geographic neighbors or, more often, disregarded altogether. The story of the ecology session at the ICAS challenges this tendency within the history of science. It makes clear that early ecologists functioned more as a social network than a discipline, one where information regularly crisscrossed the globe and incorporated the activities of both scientists and interested amateurs. The speakers were demonstrably aware of the history of their discipline, engaged with one another's work, and defensive about the continuing need for well-funded field research. They anticipated studies being conducted by a new generation of interdisciplinary-minded ecologists to better understand species adaptation to climate, and ongoing species extinction. Beginning with the scientists involved in the ICAS, it is possible to use their intellectual biographies to assess how they were involved in the wider network.

Research in life sciences was undertaken in most of the territories governed by the industrialized, imperial nations. Biologists were often willing to cross borders, switch allegiances, and pursue their careers wherever opportunities afforded themselves. The early history of ecology is a case study of how knowledge moves. The notion of ecology constituting a network has been explored by historian Raf De Bont and his argument will be supported through this examination of the published proceedings of the ICAS.[4] The proceedings have rarely been used by historians of science, likely because the content looked to the past did not focus on new findings. The significance of the Congress and the Exposition that hosted it seems to have been lost even on many of the attendees. Because speakers traveled on tight itineraries, many were unable to enjoy the exposition to its full. The mathematician Jean-Gaston Darboux (1842-1917) from the Paris Academy of Science is one example of a speaker that lamented being unable to spend more time with the exhibits on the main fairgrounds.[5] Geographer Hugh Robert Mills was also pressed for time: before the start of the ICAS he was the keynote for the Eighth International Geographical Congress in Washington. He then led the group to the LPE to complete their meetings as a session within the ICAS, and after his speech immediately set out for an excursion to the Grand Canyon

4 Raf De Bont, "Organisms in Their Milieu: Alfred Giard, His Pupils, and Early Ethology, 1870–1930," *Isis* 101, no. 1 (2010), 8.

5 Howard Jason Rogers, "The History of the Congress" *International Congress Of Arts And Science* 1. Ed. by Howard Jason Rogers. St. Louis: University Alliance, 1908), 37. Rogers provides a translation of Darboux's remarks from the closing banquet, which were in French.

before returning to London.[6] The event itself was beset with difficulties related to participation, accommodation, and sound. Yet the proceedings of the ICAS are a gem for present-day historians of science because the transcribed speeches offer a time capsule of intellectual thought from leading scientists in the years directly preceding the outbreak of the Great War, when life science was at a critical juncture. The value here lies in its potential as a resource to re-create the connections and influences of early ecological thought. The remaining sections of this chapter provide context for the content of the proceedings, explaining who participated in the ICAS, what they hoped to accomplish, and what they actually experienced that week.

The Theme and Mandate

Universal expositions before 1915 are often analyzed as examples of spectacle and consumerism, but are less often recognized as sites of science and innovation. The St. Louis World Fair is remembered for the excesses of the entertainment section, "the Pike," rather than for its contributions to science. Major expositions, however, offered numerous examples of knowledge transfer and innovation across their lavishly landscaped fairgrounds. The LPE staged the first successful demonstration of several new technologies in the United States, including meteorological balloon experiments, wireless telegraphy between the ground and the air, and two free sustained aeronautic flights. Demonstrations of coal-testing, gold refineries, printing presses, and the manufacture of liquid air were all wildly popular. The research of Agricultural Experiment stations were heavily promoted by the United States Department of Agriculture and led to exhibit designer William Jasper Spillman teaching university extension classes on a new topic, "Agricultural Economics."[7] Finally, the ICAS itself was an innovation, encouraging leading scholars to commingle and explore interdisciplinary questions in order to meet the mandate to unify knowledge.

The initial impetus for the LPE was local, and the lead organizers, former Governor David Rowland Francis and Missouri Congressman Richard Bartholdt, garnered the city's powerful elite in order to ensure their bid would be successful and the exposition would be financially viable.[8] An industrializing metropolis experiencing a boom, St. Louis was considered ideal to serve as host to the LPE. It was also regarded as the "Gateway to the West" that connected eastern states

6 Hugh Robert Mill, *Hugh Robert Mill: An Autobiography (London: Longmans, Green and Co., 1951), 174.* (London: Longmans, Green and Co., 1951), 174.

7 Laurie M. Carlson, *William J. Spillman and the Birth of Agricultural Economics* (Missouri: University of Missouri, 2005), 51. Outside the Palace of Agriculture, Spillman created a map of the United States that covered five acres, and each state area was planted with its major crops for visitors to peruse. The "birds eye" view of the exhibit was intended for observers riding the Ferris wheel.

8 Astrid Böger, *Envisioning the Nation: The Early American World's Fairs and the Formation of Culture* (Frankfurt: Campus, 2010), 171.

with the west via both rail lines and river traffic.[9] Academic historiography on this exposition has prioritized commercial aspects of the event, which has also been described as one of "the most extravagant cultural events staged in modern history."[10] The city was to be depicted as thriving, both economically and culturally, and historian James Gilbert emphasizes that this portrayal "was as much a part of the planning and execution of the Fair as any other element."[11] Visually, this message was accomplished through size. The exposition was the largest universal exposition held to date.[12] Organizers encouraged local commercial interests to rent space for everything from industrial machinery down to individual hucksters hawking fair food, rides and sundry forms of entertainment.

The community used the opportunity to build municipal infrastructure, as was customary with all the universal expositions since Prince Albert initiated the concept with London's Crystal Palace in 1851. Budgetary allocations were used to develop sanitary and policing systems. In St. Louis, the planners also decided to hollow out a natural habitat on the edge of the city, Forest Park.[13] They redirected the Des Peres River, installed a new water system, and reshaped a natural lake into a showcase water basin. Even with these physical allocations, the Fair outgrew the assigned grounds and planners negotiated a lease with Washington University, utilizing the core buildings of the new campus. Temporary palaces for Fine Arts, Electricity and Machinery, and Education were constructed in a *Beaux Arts* style, collectively creating what became known as the Ivory City. Festival Hall presided over the artificial lake and housed most of the official ceremonies.

The Louisiana Purchase Exposition commemorated an event that the planners saw as tremendously important to the American nation, second only to the signing of the Declaration of Independence.[14] The Missouri Historical Society formed a convention of 93 delegates who met on January 10, 1899, and agreed that an exposition held in St. Louis would demonstrate what had been accomplished within the region over the previous century.[15] An executive committee was

9 *Ibid*., 177.

10 James Burkhart Gilbert, *Whose Fair?: Experience, Memory, and the History of the Great St. Louis Exposition* (Chicago: University of Chicago, 2009), 13. See also similar discussion in Nancy J. Parezo, *Anthropology Goes to the Fair: The 1904 Louisiana Purchase Exposition*, Critical Studies in the History of Anthropology (Lincoln: University of Nebraska, 2007), 1-4; John E. Findling and Kimberly D. Pelle, *Historical Dictionary of World's Fairs and Expositions, 1851-1988* (New York: Greenwood Press, 1990).

11 Gilbert, *Whose Fair?*, 24.

12 Böger, *Envisioning the Nation*, 174.

13 *Ibid*., 179.

14 Board of Lady Managers of the Louisiana Purchase Exposition, *Report to the Louisiana Purchase Exposition Commission*, (Cambridge, Mass.: The Riverside Press, 1905), 9.

15 *Ibid*., 10-11.

established, which raised 10 million dollars, and a bill was passed in Congress on March 3, 1901, securing an additional $5 million towards hosting the event. The American federal government believed the LPE would be a platform to demonstrate American political and economic might. It represented an opportunity to present American technological advancements, military stockpiles, and scientific collections to international invitees. American states and territories would compete with one another to showcase various natural resources within their borders.[16]

Academic work on the Fair has relied heavily on the writings of David Francis, who left a deluge of published and archival material in his wake after serving as president of the Fair. Francis, a former grain broker turned career politician, gave numerous speeches on the fairgrounds and promoted the Fair elsewhere in the country. His ideas formed the basis of all material issued by the publicity department. He also spearheaded an official history for the LPE, which was released in 1913.[17] The history devotes a large section to celebrating Western expansionism in North America.[18] Recent political events were also acknowledged in the exhibits and publications, including American intervention in the Philippines. In fact, justification for a long-term expansionist policy was a major facet of the overarching narrative of the Fair.[19]

The notion that political dominance was pre-ordained by racial superiority was illustrated by anthropological exhibits showing "villages" of representative races within American territories, including Native Americans and Filipino Igorot families. Many of the exhibits circulated ideas under the guise of anthropology that are at best problematic. Historian James Gilbert analyzed the cultural messages of these exhibits, along with attendance figures, audience expectations, and pageantry for the Fair. [20] Historian Paul Michael Lutzeler, on the other hand, focused on cultural transfer and exchange that took place between participating countries.[21]

Historians also emphasized ethnic tensions that were evident in the preparations at the LPE. Twenty percent of the St. Louis population was foreign-born and another forty percent had foreign-born parents. The large local German population proved pivotal to encouraging Germany

---

16

17 Gilbert, *Whose Fair?*, 38.

18 Expansion was considered evidence of success. The organizers were also defensive about the location of the Exposition: "The heart of the Mississippi was not exactly Nazareth out of which no good thing could come," wrote Mark Bennitt in the official history, "but it was unknown land, and the ability of its people to produce such an Exposition was doubted long after the gates were open." See Bennitt, CITE

19 *Ibid*., 51. See also the brief discussion of the political agenda of the fair in Julie K. Brown, *Health and Medicine on Display: International Expositions in the United States, 1876-1904* (Cambridge, Mass.: MIT Press, 2009), 124.

20 Gilbert, *Whose Fair?*, 39.

21 Paul Michael Lützeler, "The St. Louis World's Fair of 1904 as a Site of Cultural Transfer: German and German-American Participation," in *German Culture in Nineteenth-Century America: Reception, Adaptation, Transformation*, ed. Lynne Tatlock and Matt Erlin (Rochester: Camden House, 2005), 60.

to provide a strong presence throughout the fairgrounds.[22] German culture was more thoroughly represented than most of the other countries, although this presence reflected contemporary political realities as much as local cultural affinities. For example, although there was also a large local Irish population, Irish exhibits were relegated to the entertainment-oriented Pike, as were the Filipino and Native American displays.[23] The focus on the activities on the Pike, the "human zoos" (a colloquial term for the ethnological exhibits of this era), and the enduring popularity of songs and movies about the Fair released after the fact, have obscured the overarching mandate of the LPE, which was to unify all knowledge.

The LPE functioned as a major site of knowledge transfer. There was a strong educational component for the attendees, and fairgoers received demonstrations on everything from the efficacy of agricultural experiment stations to model schools for the underprivileged (e.g. the deaf, Aboriginals). Many of these displays were banal, according to educationist Hanzlik-Green, although the demonstrations in the industrial education section were spectacular, featuring moving displays of equipment and training exercises.[24] At the LPE, the idea of "education characterized by life and motion" provided cohesion and focus. Historian Astrid Böger noted that the thematic approach distinguished the LPE as the precursor to today's world fairs, which no longer attempt to represent all areas and life but instead restrict displays to discuss a single idea.[25]

The LPE, like all major expositions of the imperial age, received government support because it enhanced commercial opportunities and exhibited science, industry, and progress for the public. Recent academic work, like that of Hanzlik-Green, explored the role of the LPE as a meeting space for the international exchange of ideas. She argued it was especially significant that the promoters "saw the event's target audience – the masses – as worthy and capable of learning."[26] The planners provided a Palace of Education, a grand, centralized structure that visually supported their claim that education was central to all progress. The 338,000 square-foot behemoth held exhibitors from 42 American states and 62 foreign countries and colonies, and advertised what they offered in nursery, kindergarten, secondary, post-secondary, commercial, agricultural, industrial, technical, artistic, and normal schooling. Hanzlik-Green confirmed that the Congress sought to connect education and progress. Historian Julie Brown reached the same conclusion about the exhibits on health and medicine at the Fair, although she also revealed a disconnect between promotional rhetoric on progress and the struggles the site services staff faced in maintaining

22 Gilbert, *Whose Fair?*, 23.

23 Christie Cern Hanzlik, "Education Beyond Borders: Exchanging Ideas through World's Fairs, Congresses, and Academic Journals, 1851 to 1904." (University of Wisconsin - Madison, 2010), 103-8.

24 *Ibid*., 56-7.

25 Böger, *Envisioning the Nation*, 187.

26 Hanzlik, "Education Beyond Borders," 70-72. Quote on p 70.

quality water supplies and emergency health services for fairgoers.[27] Historians George Haines and Frederick Jackson claimed that the ICAS constituted a neglected landmark in intellectual history. Historian Lawrence Scaff discussed how sociologist Max Weber's work was influenced by his attendance at the ICAS and his subsequent tour of the Oklahoma territories, while mathematician David Zitarelli acknowledged the role of the ICAS in consolidating networks of mathematicians.[28]

Confirmation of the widespread cultural and intellectual impact of the LPE is growing, but none of these accomplishments were assured when, by proclamation of President William McKinley on August 20, 1901, the United States invited "all the nations of the earth" to take part in the celebration of a pivotal event in world history. Creating a space for knowledge exchange presented a formidable challenge for the planners right until opening day.

The International Community

By 1900, a community of imperial nations that viewed themselves as competitors with one another were in fact cooperating to integrate their resources, including human resources, into a global economy. Great Britain, France, Germany, Japan, and the United States were utilizing similar concepts and approaches, and they drew upon a single pool of candidates that were willing to relocate into newly acquired territories. The "empire project," as historian John Darwin has discussed, created conditions where individuals could sell their skills, relocate or emigrate in a way that had not been seen before, particularly in scientific circles.[29] Because of the porous nature of the young nation-states, universal expositions became sites of recruitment, trade, and intellectual exchange. The multi-ethnic quality of imperialism was demonstrated in the history of the planning of the LPE, but the lingering allegiance of individuals to their original homelands is also clear. Nowhere was this more evident at the St. Louis World Fair than during the ICAS, when hundreds of academics with international stature were recruited for a dual purpose: to come and present to the public how their fields had progressed over the previous century, and to overcome the pervading trend towards specialization.

The response of the international community to these invitations has not been extensively examined. The official histories were overly positive in tone, and the critical examinations of the pageantry and exhibits did not include the motives for the participation of foreign governments.

---

27 Julie K. Brown, *Health and Medicine on Display: International Expositions in the United States, 1876-1904* (Cambridge, Mass.: MIT Press, 2009), 124-5.

28 David E. Zitarelli, "The 1904 St. Louis Congress and Westward Expansion of American Mathematics," *Notices of the American Mathematical Society* 58, no. 8 (2011); George (IV) Haines and Frederick H. Jackson, "A Neglected Landmark in the History of Ideas," *The Mississippi Valley Historical Review* 34, no. 2 (1947); Lawrence A. Scaff, *Max Weber in America* (Massachusetts: Princeton University Press, 2011), 58-66.

29 John Darwin, *The Empire Project: The Rise and Fall of the British World-System, 1830-1970* (Cambridge, UK: Cambridge University Press, 2009).

Foreign participation was necessary to support the claim that the exposition was "universal," and the blatant reluctance of European nations to commit resources to the LPE threatened the feasibility of the entire enterprise. In the end, Germany was the first nation to display interest. Consequently, even though the LPE was ostensibly being held to honor the French sale of territory to the United States, the attendees of the ICAS found themselves participating in an event that was heavily dominated by the United States and Germany. English academics were also well represented, and France would insist on maintaining a presence, but neither country made their commitments without reservations. The American organizers were able to overcome this resistance.

In Great Britain, the invitation to participate in the Louisiana Purchase Exposition was outright unwelcome. The Foreign Office, then led by Henry Charles Keith Petty-Fitzmaurice, 5th Marquess of Lansdowne considered it undesirable to hold a large International Exhibition so soon after the *Exposition Universelle* in Paris, 1900. In particular, the expense of representation was difficult to justify. A letter from the Treasury Chambers to Lord Landsdowne dated December 12, 1901 indicated that only because the ministry was of the opinion that the United States Government should not be outright declined, 200 GBP would be allotted to compensate a representative assigned to the Exhibition.[30] The initial decision was to send a collection of art for display. Hanzlik-Green speculated it was the interest expressed from London to send a pavilion on arts and education that led the Fair President David Francis to promote education at the Fair.[31] On February 14, Henry White, First Secretary of the American Embassy in London, forwarded a letter from Francis expressing his desire that the West Indian Colonies be permitted to participate. This request was ignored.

Commitment from Europe remained lukewarm and therefore preparations lagged, necessitating a postponement of the Fair date to a year later than what would have been the exact centenary of the Louisiana Purchase. Francis next sent a personal envoy, American congressman Willie James Buchanon, to London with a letter of introduction and orders to press the matter of British participation in the Fair. Buchanon explained that other foreign countries were reluctant to reply until Great Britain agreed to participate, and asked for a Royal Commission to be appointed with the Prince of Wales as President.[32] In a memorandum on the visit, it was indicated that such a

30 Letter from Francis Mowatt at Treasury Chambers to Secretary of State for Foreign Affairs, December 12, 1901. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2513). National Archives at Kew, United Kingdom. The amount was based on the sum sanctioned for representation at New Orleans in 1884, without adjustments for inflation.

31 Hanzlik, "Education Beyond Borders," 77.

32 Anonymous, approx. July 1902. "St. Louis Exhibition." Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2513). National Archives at Kew, United Kingdom. Item is an undated, unsigned draft of an internal memorandum regarding participation in the Louisiana Purchase Exposition.

request was not reasonable, but a 5000 GBP grant could be offered "for the credit of this country and to please the American national sentiment." [33] It was also noted that 100,000 GBP was spent at Paris, and the results (in terms of trade and prizes) were disappointing. Considering the high American tariff, commercial success at St. Louis was also considered unlikely. Great Britain would not participate further until Germany indicated it was making a more fulsome commitment.

Sir Francis Cavendish Lascelles, who represented the British government in Berlin, wrote on May 19, 1902, that "no decision has yet been taken as to representation of Germany at St. Louis Exhibition or as to financial grant."[34] Hanzlik-Green noted that European business owners "felt burned by their participation at previous US Fairs and were, in their words, 'sick of the fairs in general.'"[35] The American press reported that German publishers and industrialists were boycotting the LPE because at previous fairs US companies were unethically copying and profiting from items on display.[36] The German government nevertheless intended to take advantage of the opportunity in order to encourage friendly relations with the United States. Paris 1900 may have exhausted the European appetite for expositions, but it had also been instructive concerning the potential to increase trade and collect prize winnings. The USA was Germany's second most important trading partner, after Great Britain, and it was believed the offer to attend could not be ignored.

Reports from Lascelles continued until November of 1902, always downplaying the extent to which Germany planned to participate in the exposition. In the meantime, a great deal of effort was expended by Francis to convince German officials to contribute to the project. Gaining their trust proved to be a serious challenge, since the proposed fair celebrated the sale of Louisiana, which Napoleon Bonaparte had used to fund the French war machine and instigate a decade of domination over continental Europe. As much as Germany was interested in promoting its culture and industry to Americans, the attempt to add gravity to the Fair through memorialization had backfired: instead, portions of the international community were put off by American insensitivity. Francis broke the stalemate by assuring Kaiser Wilhelm that there was a robust German-American community in St. Louis and demonstrating there was an opportunity to enhance Germany's image at the Fair.[37] The Kaiser showed the most interest in the planned Congress.[38] This initial endorsement proved crucial to the success of the ICAS.

---

33 *Ibid*. The issue of high tariffs and heavy transportation costs for exhibit goods was incendiary and is thoroughly discussed in the Foreign Office correspondence.

34 Sir Francis Lascelles, 19 May 1902. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2513).National Archives at Kew.

35 Hanzlik, "Education Beyond Borders," 73.

36 *Ibid*.

37 Lützeler, "The St. Louis World's Fair of 1904," 62; see also Hanzlik, 109.

38 Hanzlik, "Education Beyond Borders," 146.

On November 5, 1902, British internal reports on the progress of the exposition planning in Germany were taken up by William S.H. Gastrell, who indicated that German interest in the exposition was increasing.[39] Theodor Lewald, the diplomat who had served in the same capacity at Chicago in 1893 and at Paris in 1900, was appointed the German Commissioner for the Fair and immediately left for America to secure the best possible locations for German exhibits.[40] Hist strategy was successful: Lewald landed a strategic position for the German pavilion next to Festival Hall,[41] and Germany became the only national pavilion that was part of the main venue of the Fair.[42] The pavilion they created was a copy of the Kaiser's Charlottenburg Palace in Berlin. In addition, a Tyrolean Village was constructed for the Pike, one of the most attractive and well-attended venues in the entertainment section.[43]

Figure 2.3. German pavilion, Louisiana Purchase Exposition, 1904.[44]

39 Memorandum from William S.H. Gastrell, stationed in Berlin. November 5, 1902. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2513). National Archives at Kew.

40 Lewald's immediate concern was to secure space for the art exhibits and organize their content, which was a surprisingly contentious issue within Germany. A division was entrenched between the Prussian Academy of Arts and its art school on one side, and on the other the regional secessionist movements. Into this debate the Kaiser's hostility towards modern art had to be considered. Lewald initially hoped to showcase a variety of styles, but in the end lost out to royal preferences. Therefore, the artists of the famous secession movement (e.g. Gustav Klimt) were not shown at St. Louis. See Lawrence A. Scaff, *Max Weber in America* (Mass.: Princeton University Press, 2011), 67.

41 Hanzlik, "Education Beyond Borders," 110.

42 Lützeler, "The St. Louis World Fair," 62.

43 *Ibid*., 80.

44 "The German Building." From Mark Bennitt, *History of the Louisiana Purchase Exposition* (St. Louis: Universal Exposition Publishing Company, 1905), 251. Photograph by William H. Rau. Public domain.

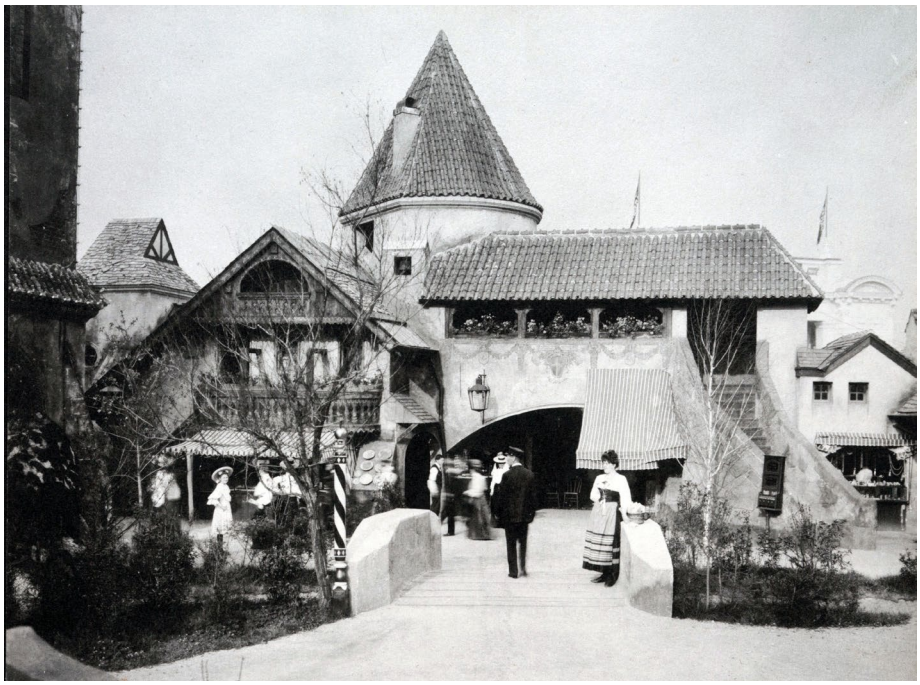

Figure 2.4. Tyrolean style village, Louisiana Purchase Exposition.[45]

The Germans, who were initially loathe to participate at all, had completely reversed their position once the Emperor discovered the large German-born segment of the St. Louis population. The thriving local community of Hegelians and German ethnic clubs were thrilled with the interest and eager to display their heritage. A core group of Teutonic enthusiasts at Harvard then became intent on using this Fair to encourage German-American intellectual exchange. Plans were again adjusted by the St. Louis organizers. The Kaiser's brother, Prince Henry, visited America in order to witness the preparations and he subsequently encouraged Germany to increase its financial commitment.[46] Soon sufficient funds were allotted so that on opening day, visitors found a German pavilion in the main thoroughfare, a Tyrolean village in the Pike, and German educational exhibits that sprawled over 4,400 square feet in the Palace of Education, dwarfing the submissions of the other countries.

In reaction to German interest, France increased its commitment. A report appeared at the Foreign Office in London in late 1902 that indicated a *Comité Français des Expositions à l'Étranger* had just been formed to organize the French section of displays, and a Bill had been laid before the Chamber of Deputies authorizing a total expenditure of 649,000 FR, an increase

45 "Louisiana Purchase Exposition." 1904. Ernest M. A. Machado Collection. MIT Libraries Visual Collections, Massachusetts Institute of Technology. Accessed June 13, 2016: http://hdl.handle.net/1721.3/177181. Original copyright Louisiana Purchase Exposition, now in public domain.

46 Bennitt, *History of the Louisiana Purchase Exposition*, 101. See also Lützeler, "The St. Louis World's Fair of 1904," 62.

of 49,000 beyond the budget initially contemplated.[47] French participation was expected to be limited to exhibits on the arts, electricity, and education. By this time, the British Foreign Office was receiving domestic pressure as well. In the House of Commons on 18 December, 1902, a question was posed regarding the preparations being made for British representation at the St. Louis Exposition, specifically why a Royal Commission had yet to be appointed. Former Prime Minister Viscount Cranborne responded that "the question is still under consideration, and I am not in a position to make any statement on the subject at present."[48] Despite the fact that Britain was moving away from its isolationist policy during these same years and Lord Lansdowne was seeking friendly alliances with other imperial nations, the exposition was clearly not a priority. The main issue seemed to be cost. British diplomats hoped that domestic exhibitors would take on the majority of the expense for displays, but the commercial sector declined for the same reasons that German industry had: limited sales at previous fairs, and frustration with unscrupulous copying of designs. Officials in Britain finally relented and opted to appoint a Committee (unambiguously declaring that it was "not a Commission") to administer a small grant for participation. The British exhibit was to be confined to education, fine arts, and the productions of Government departments, including weapons displays from the national armory at Woolich.[49]

Another memorandum from Gastrell in Berlin was sent to the Foreign Office in London on January 9, 1903 that discussed Germany and the St. Louis Exhibition at length; it claimed the German Empire had granted the equivalent of 75,000 GBP for the expenses of representation at the Louisiana Purchase Exposition.[50] That sum was the first installment of what was expected to be

47 Summary of replies from Foreign Government as to their participation in St. Louis Exhibition. November 12, 1902. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2513). National Archives at Kew.

48 Excerpt of question and answer. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2513).National Archives at Kew. Viscount Cranborne was the styled name of Robert Arthur Talbot Gascoyne-Cecil, 3rd marquess of Salisbury (1830–1903), was Prime Minister and personally oversaw the Foreign Office, when he handed over the latter to Henry Petty-Fitzmaurice, 5th Marquess of Lansdowne. Cranborne retired from being the Prime Minister in July. His nephew, Arthur Balfour, became the next Prime Minister.

49 Letter from F.A. Campbell to Mr. Morant. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2541). National Archives at Kew. The effort to avoid terminology associated with Commissions, which appears to have been a method of impeding financial escalation, was finally abandoned in July, 1903, when the appointed Secretary pleaded with the Foreign Office to change his title to Commissioner, since "the term Secretary does not convey to the American Authorities of the Exhibition the nature of my duties." See Letter from Colonel Charles Moore Watson to the Inter-Secretary of State, Foreign Office in same file.

50 William S.H. Gastrell, "Memorandum on Germany and the St. Louis Exhibition," in Foreign Office, General Correspondence from Political and Other Departments before 1906, United States of America, Series II, FO 5/2541 (United Kingdom: The National Archives at Kew, 1903).

no less than 2,500,000 ℳ total expenditure. The German exhibits would focus on art, the methods of education, the book trade, and scientific apparatus of all kinds. The phenomenon of Americans pursuing advanced education in Germany was well-known, and these displays were thought to encourage potential students. German universities used expositions to promote their scientific reputation. It was also remembered from the Paris Exhibition that Americans were major buyers of art. Gastrell attached an article from the *Norddeutsche Zeitung* on "The Participation of the German Empire at the St Louis Exhibition" where attention was called to the increasing proportion of German products in the foreign trade of the United States. The strategy was to create exchange opportunities and extend trade at the expense of France and Great Britain. A subsequent letter from Francis confirmed that Germany's preparations were much further along than any other invitees.[51]

The Foreign Office and Treasury in London remained unmoved under mounting requests from exposition organizers, American ambassadors, and their own colonial offices. English educationist Michael Sadler submitted an unsolicited memo to the Foreign Office objecting to the diminutive grant allotments. He claimed "more harm than good would be done if Great Britain were shabbily represented at St. Louis."[52] Sadler had recently traveled in the US and argued forcibly for Britain to take "an effective part in the Exhibition." He correctly explained that "these Universal Expositions assume in the United States an importance which has rarely been attached to them in Europe," citing the expositions in Philadelphia in 1876 and Chicago in 1893 as being important to the advancement of culture, art and social organization in North America. He described them as "epoch-making to a degree which has only been true of one European exhibition," by which he meant the Crystal Palace. He suggested that the central location of the Louisiana Purchase Exposition (between eastern and western states) would attract an "immense and energetic population" that would be experiencing a universal exposition for the first time. He noted that generous budgets had been allotted to entertain foreign visitors and defray their costs. Apart from the industrial and commercial importance, the exposition was to "have great intellectual and artistic significance for the whole of North America." Then he got to the crux of the matter:

> *This is fully recognized, I am told, by the German Government. The latter is going to make a great effort to bring the products of German art and industry and the outcome of German scientific and educational organization in the most attractive light before the American public.*[53]

51 David R. Francis, "Letter from David R. Francis to Joseph H. Choate, Ambassador of the U.S. American Legation," in Foreign Office, General Correspondence from Political and Other Departments before 1906, United States of America, Series II, FO 5/2541 (United Kingdom: The National Archives at Kew, 1903).

52 Memorandum from Michael Sadler, August 27, 1902. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2513). National Archives at Kew.

53 *Ibid.*

Sadler's view prevailed, and the various members of the committee began to cite the memorandum when requesting more realistic budgets for their exhibits.

Great Britain would not participate as extensively as Germany in the industry and education pavilions, but eventually embraced the marketing potential of the exhibition. Its former colony Canada, for example, did not contribute to any of the exhibits but instead tantalized attendees with a lavish pavilion designed to encourage agriculturalists to relocate and homestead across the border. The Canadian Pavilion became known as "The Clubhouse." Canada also indirectly facilitated other displays, as Sir Eric Barrington, private secretary to the Marquess of Lansdowne, indicated in a letter to British Fair Commissioner Colonel Charles Watson:

> *Do you know that the King agreed to send more of the late Queen's presents to the St. Louis Exhibition? Lord Strathcona induced H.M. to let them be exhibited first at Toronto where they have gone in charge of a Mr. Christie. When done with, he will take them on to St. Louis and hand them over to* "a qui de droit," [sic] *but their expense from the Canadian frontier will have to be defrayed by H.M.G., and presumably out of the vote for the Exhibition.*[54]

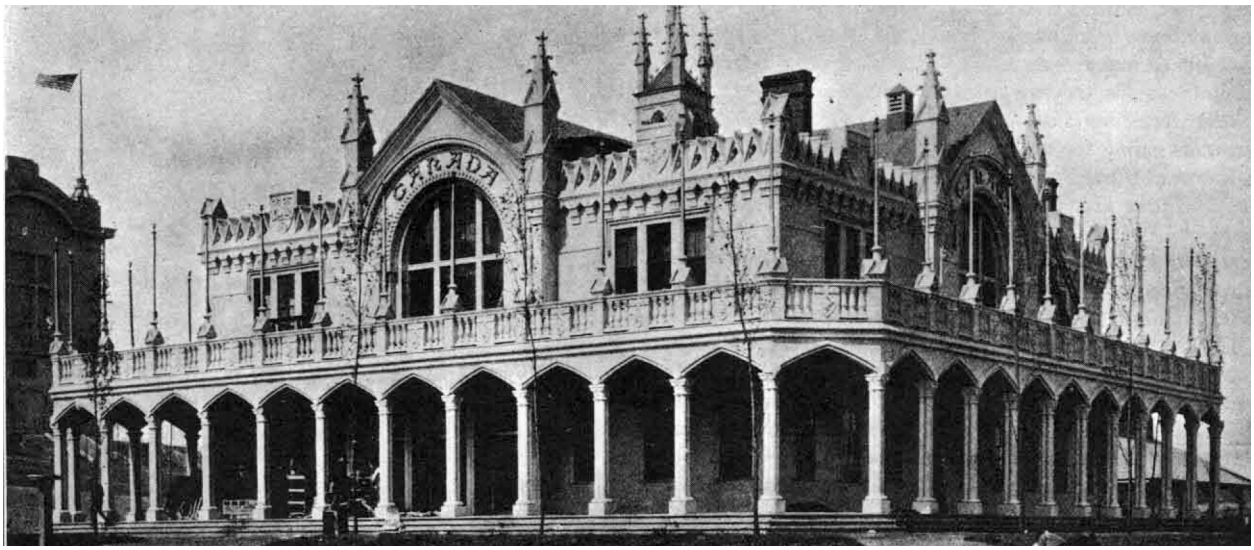

Figure 2.5. Canadian pavilion, Louisiana Purchase Exposition, 1904.[55]

54 Letter from Eric Barrington of the Foreign Office to Colonel Watson, 8 August 1903. Foreign Office, Political and Other Departments, General Correspondence Before 1906, United States of America, Series II (FO 5/2541). National Archives at Kew.

55 In Bennitt, *History of the Louisiana Purchase Exposition*, 218. Photograph by William H. Rau. Public domain.

As a result of the competitive spirit between Great Britain and Germany, carefully cultivated by fair organizers and British diplomats, more foreign countries participated at the LPE and to a greater extent than at any previous American exposition. These commitments increased the networking impact of the Congress exponentially.

The Planning Committee

The ICAS proceedings reveal the dominance of the Anglo and German scientific communities during the Victorian and Edwardian periods, throughout the industrialized world. British influence in America was to be expected because of the political and linguistic background shared with Canadian and American people. American-German cooperation was also common during the century of western settlement before the outbreak of general war in 1914. Christie Hanzlik-Green studied the considerable influence of German thought in western North America before 1914. Her results confirmed the work of historian Eckhardt Fuchs, who documented the growth of international congresses over fifty years beginning with the 1860s. In all the decades Fuchs surveyed, the largest number of Congresses always coincided with a major exposition and Hanzlik-Green agreess that an international community of scholars was created at these events.[56]

The ICAS was patterned after a number of successful conferences and congresses held during expositions in Paris (1867, 1878, 1900), Philadelphia (1876), Vienna (1873), and Chicago (1893). In 1900, the Fair in Paris featured 125 congresses with separate organizational committees, but overall attendance was disappointing.[57] Such poor uptake at the Paris congresses alarmed the ICAS planning committee. The Paris congresses were located in a major capital that featured convenient travel connections and a reputation as "the home of arts and letters," advantages that St. Louis did not offer. They decided that intervention at a high level of the planning stage would be required in order to make formal academic work at St. Louis viable. At Paris, the attendees were overwhelmingly European. If planned properly, the ICAS had the potential to be more truly universal in terms of participation and content, and could also benefit the academic community:

> *No exposition was ever better fitted to serve as the groundwork of a congress of ideas than that of St. Louis. The ideal of the Exposition … was its educational influence. Its appeal to the citizens of the United States for support, to the Federal Congress for appropriations, and to foreign governments for cooperation, was made purely on that basis.*[58]

56 Hanzlik, "Education Beyond Borders," 148-9.

57 Howard Jason Rogers, "The History of the Congress," 2.

58 *Ibid.*

The exposition planners prioritized the recruitment of high-profile international speakers.[59] They secured travel funds both for the committee to use while soliciting participation, and for the speakers themselves to attend.[60] By the time the proceedings were published, it was clear that their efforts were well-rewarded and perhaps even too successful: rather than complementing a celebration of American scholarship, European content once again dominated the academic work.

The administrative board included presidents of many of the leading educational institutions in the country. Among them were Nicholas Murray Butler from Columbia University, William Rainey Harper from the University of Chicago, and Henry Smith Pritchett from the Massachusetts Institute of Technology. The committee also included Herbert Putnam, the Librarian of Congress, and Frederick J.V. Skiff, the Director of the Field Columbia Museum. Skiff insisted that congress work ought to stand for something "more than an unrelated series of independent gatherings, and that some project be authorized which would at once be distinctive and of real scientific worth."[61] The lone lawyer amid the intellectuals, Frederick William Holls, proposed that "a series of lectures on scientific and literary topics by men prominent in their respective fields be delivered at the Exposition and that the Exposition pay the speakers for their services."[62]

Hugo Münsterberg, a German-American professor of psychology at Harvard and one of the first psychologists to apply evolutionary theory to the origin of ethics, was a guest of Holls at the time.[63] Münsterberg and Holls were close friends, and both men traveled in lofty circles. Holls was a member of the Hague tribunal and a correspondent of the Pope, and Münsterberg was friends with Theodore Roosevelt. The Münsterberg home in Cambridge, Massachusetts, was a favoured stopover for many visiting dignitaries.[64] He had entertained Prince Henry, brother of Kaiser Wilhelm, when the royal visitor toured the USA in 1902. During the visit, Prince Henry was given an honorary degree from Harvard, and was feted at the Germanic Museum Association, one of Münsterberg's pet projects.[65] Among other political affiliations, Münsterberg and Holls shared "a strong hope for a cordial alliance of the three Teutonic nations."[66] Upon hearing of the committee's struggles, Münsterberg suggested that a series of unrelated lectures would have

59 Hanzlik, "Education Beyond Borders," 153.

60 Zitarelli, "The 1904 St. Louis Congress," 1100-1.

61 Howard Jason Rogers, "History of the Congress," 5.

62 *Ibid*. See also discussion in Margarete A. Münsterberg, *Hugo Münsterberg, His Life and Work* (New York: D. Appleton and Company, 1922), 96-100.

63 Jutta Spillmann and Lothar Spillmann, "The Rise and Fall of Hugo Münsterberg," *Journal of the History of the Behavioral Sciences* 29, no. 4 (1993): 323.

64 *Ibid*., 326.

65 Münsterberg, *Hugo Münsterberg*, 83-88.

66 *Ibid*.

little scientific value. His daughter, Margaret, recalled that her father thought "that the opportunity offered by the gathering of scholars at a World's Fair might be used for some constructive, creative work."[67] He believed that better results would be obtained if some relationship between the lectures could be introduced and argued that only under these conditions would the scientific leaders of Europe be likely to embrace the ICAS.[68] Holls requested that Münsterberg submit a formal plan. So began Münsterberg's involvement with the ICAS, in which he would encounter a wide variety of problems ranging from opposition to his program from philosophical pragmatists, to demands from politicians that the session speakers be allotted by national quotas,[69] to practical concerns such as finding dormitories to house the hundreds of single, male scientists in attendance.

According to historian Lawrence Scaff, Münsterberg believed that "the time had arrived to overcome the materialism that dominated the nineteenth century by working out a new foundation for knowledge."[70] Münsterberg later reminisced that the location of the Fair lent itself well to the proposal he created:

> *St. Louis had asked the nations of the world to a celebration of the Louisiana Purchase. Historical thoughts thus gave meaning and importance to the whole undertaking. The pride of one century's development had stimulated the gigantic work from its inception. An immense territory had been transformed from a half wilderness into a land with a rich civilization, and with a central city in which eight thousand factories are at work. No thought lay nearer than to ask how far this century was of similar importance for the changes in the world of thought. How have the sciences developed themselves since the days of the Louisiana Purchase? That is a topic which with complete uniformity might be asked from every special science, and which might thus offer a certain unity of aim to scholars of all scientific denominations.*[71]

Münsterberg carefully created a framework that could look both forwards and backwards. He believed that if the ICAS were a purely commemorative event "a kind of necrological sentiment would pervade the whole ceremony."[72] Important intellectual issues arose out the structure of his program, however, which Scaff claims set the"foundationalist conception of the logical structure

---

67 *Ibid.,* 97.

68 Rogers, "The History of the Congress," 5.

69 Gilbert, *Whose Fair?*, 27.

70 Scaff, *Max Weber in America,* 55.

71 Hugo Münsterberg, "The Scientific Plan of the Congress" *International Congress of Arts of Science* 1, Ed. Howard Jason Rogers. St. Louis: University Alliance, 1908), 88. He is referring to the days of the Louisiana Purchase because the Fair celebrating the centenary of Jefferson's appropriation of the territory.

72 *Ibid*.

of knowledge against a pragmatic conception of scientific interests and activity."[73] These issues came to the forefront on December 27, 1902, when the administrative board debated Münsterberg's proposed theme, "The Progress of Man since the Louisiana Purchase."[74] Münsterberg's philosophy was no simple matter.[75] His terminology attempted to clarify the difference between the nomothetic natural sciences and idiographic humanities, but he considered the fields related nonetheless.[76] Münsterberg argued a common factor amongst all areas of knowledge was that they were, without exception, theoretical at heart. Even the *application* of knowledge itself was considered a legitimate area of inquiry. This was in contrast to the view of utilitarian fields simply being "pure knowledge" applied to a practical problem. He was committed to the idea largely "because he was eager to convince skeptical scholarly Europe of the high standard of American scholarship that had been repeatedly accused of servility to practical ends."[77] The philosophical underpinnings of his schematic were unlikely to be perceived, much less understood, by the general public. American sociologist Albion Small submitted a competing submission that suggested participants should simply aim to measure the achievement and progress of the previous century. Small's ideas more closely mirrored the mission statements of the LPE. Small expressed concerns about Münsterberg's approach and claimed the "scheme would put on display not the unity of science but the disunity of scientists."[78] Small's close friend, educationist John Dewey similarly dismissed Münsterberg's

73 Scaff, *Max Weber in America*, 55.

74 Howard Jason Rogers, "The History of the Congress," 6.

75 He saw the world in terms of subjects and objects: "The pure experience of will he recognized as subject, and the world upon which the will acted as object," explained Margaret Münsterberg. Subjects and objects could be classified as "over-individual" and "as individual." The study of over-individual subjects would be referred to as Normative Sciences. Such sciences were based on the idea that society was teleological, and grappled issues like morality and ethics—things Münsterberg referred to as norms or over-individual will-acts. Individual subjects were the result of personal will-acts (i.e. desires) and the study of these acts as they had occurred over time would be considered Historical Sciences. Over-individual objects could supposedly be accessed by any given individual. Natural phenomena would be considered over-individual, and its study would be the Natural Sciences. Individual objects, on the other hand, were created based on an individual's perception and would be associated with the Mental Sciences. On top of this complex categorization, Münsterberg's philosophy also discussed "a world of purpose," a separate "world of phenomena," and "primal essences." See discussion in Münsterberg, *Hugo Münsterberg*, 102-3; Münsterberg, "The Scientific Plan of the Congress," 103-109; A.W. Coats, "American Scholarship Comes of Age: The Louisiana Purchase Exposition 1904." *Journal of the History of Ideas* 22, no. 3 (1961), 406-8.

76 Scaff, *Max Weber in America*, 55. In Kantian philosophy, *nomothetic* describes practices within the natural sciences where universal laws can be applied to large samples of data from natural phenomena, while *idiographic* describes the more subjective, case-by-case approach used in the humanities.

77 Münsterberg, "The Scientific Plan of the Congress," 104.

78 Scaff, *Max Weber in America*, 56.

vision as a "sectarian intellectual idea."[79] Despite these concerns, when the committee compared the two submissions, Münsterberg's proposal had distinct advantages. Whatever his metaphysical claims, in the proposal 128 sections were identified that aligned with traditional disciplines.[80] if he remained involved in the planning process, they would be given access to Münsterberg's prestigious circle of European scholars. The committee chose Münsterberg's idealistic division of sciences, where almost every academic inquiry could be considered scientific, over Small's progressive, problem-centred division of scholars.

After endorsing the general concept, the Board tapped a handful of eminent men in science for the task of harmonizing scientific work in every field. Simon Newcomb, an astronomer with familial roots in Nova Scotia and professional ties to the United States Navy, was appointed President of the Congress. Press agent Howard J. Rogers described him as "the dean of American scientific circles" and "particularly fitted to preside over such an international gathering of the leading scientists of the world."[81] Hanzlik-Green agreed that Newcomb "brought unquestionable prestige to the committee."[82] Münsterberg was appointed as one of two vice-presidents, along with Albion Small. John Bassett Moore, professor of international law at Columbia, William H. Welch, professor of pathology at Johns Hopkins University, Elihu Thomson, a consulting engineer with the General Electric Company, and George Foot Moore, a professor of comparative religion at Harvard, rounded out the committee.

Unification within the academy was a personal priority for the new ICAS President. He promoted the ICAS in *Popular Science Monthly*, advocating for the effort to unify academic knowledge in the face of what he called "that almost alarming increase of specialties in scientific research, coupled as it necessarily is with lack of knowledge on the part of any one investigator…. Depressing indeed would be the prospect if scientific investigators could look forward only to an unending increase of this process of subdivision."[83] Despite general agreement of the need for unification, contention pervaded the committee regarding the best method to pursue that goal.

---

79 *Ibid*. Dewey was hinting at Münsterberg's adherence to a theory that the rational alone is real, that all reality could be sorted into rational categories, and that reality could be summarized into a synthetic unity. For further discussion see Hanzlik, "Education Beyond Borders," 155.

80 Scaff, *Max Weber in America*, 57.

81 Howard Jason Rogers, "The History of the Congress," 12.

82 From Hanzlik. Historian Ben Schaefer has suggested Newcomb was the inspiration for Sir Arthur Conan Doyle's character, James Moriarty. See *The Man Behind Moriarty* (Cambridge, Mass.: Sky Pub. Co., 1993); "Sherlock Holmes and Some Astronomical Connections" *Journal of the British Astronomical Association* 103, no.1 (1993).

83 George (IV) Haines and Frederick H. Jackson, "A Neglected Landmark in the History of Ideas," *The Mississippi Valley Historical Review* 34, no. 2 (1947).

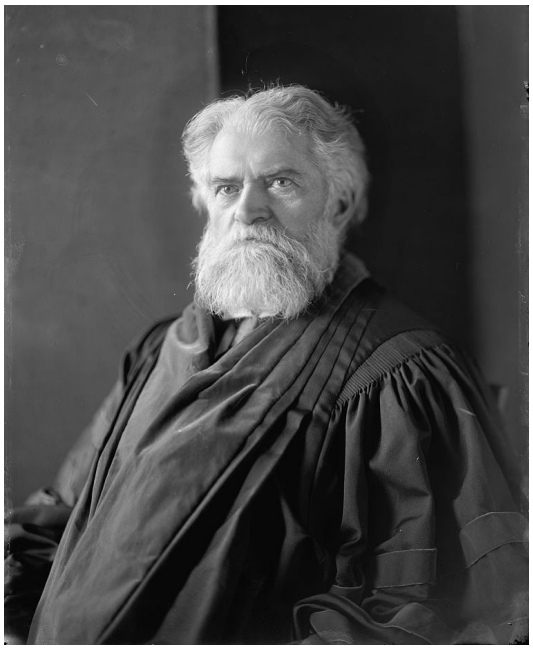

Figure 2.6. Simon Newcomb, President of the ICAS.[84]

The minutes of the first meeting reveal divisions within the group over most issues, beginning with what would be required of participants. A flare of in-fighting immediately erupted concerning the intellectual conception of how the speakers might demonstrate the idea of progress. Münsterberg defended his plan to discuss only intellectual ideas. Small attempted to convince the group that the speakers should comment not merely on advances in science, but the progress of civilization in general. Newcomb suggested that they should invite representative men of all civilized peoples and set them to debate relations between the nations and the unity of progress of the [white] race. After a heated discussion, the group reverted to Münsterberg's initial proposal that speakers each be assigned the task of "bringing out the unity of knowledge," with the attendees working from general to more specific concerns over a week of sessions. The planning committee recommended that full liberty be given to the sectional organizers regarding the general character, program, and discussions within each field proposed.[85] Every speaker would receive a 150 USD honorarium; and in addition each American speaker invited was to be offered 150 USD for his traveling expenses and each European allotted 500 USD.

By May, the committee was absorbed in encouraging participation, both foreign and domestic, and ensuring the support of "the scientific public."[86] Suitable speakers had to be found.

---

84 "Newcomb, Simon. Professor." Library of Congress Digital Collections. Photographer Harris and Ewing, approx. 1905. Available online at: http://www.loc.gov/pictures/resource/hec.16238/. No known copyright.

85 Rogers, "History of the Congress," 10.

86 *Ibid*., 15-16.

It was determined that the seven division speakers and the forty-eight department speakers that would present during the first two days of the conferences should be Americans, and they should focus on the contribution of American scholarship. Recruitment of American speakers, chairmen and secretaries occurred through correspondence by a small army of clerk and stenographers under the direction of Newcomb. Session chairs were to be men with strong personalities that had international reputation. The secretaries were to be younger men of promise and ability, chiefly from regional universities. The chairs and secretaries served without compensation. For the remainder of the speaking slots, foreigners had to be solicited in person. Newcomb, Münsterberg and Small traversed Europe separately during the summer of 1903, hosted and supported by the federal governments of the United States, England, France and Germany. In August they met in Munich to compare results and determine a final combined push to fill fields that were underrepresented.[87] Rogers emphasized the delicacy and careful adjustments required:

> *Scientists are as a class sensitive, jealous of their reputations, and loath to undertake long journeys to a distant country for congress purposes. The amount of labor devolving upon the Committee to find the scientists scattered over all Europe; the careful and painstaking presentation to each of the plan of the Congress; the appeal to their scientific pride; the hearing of a thousand objections, and the answering of each; the disappointments incurred; the substitutions made necessary at the last moment; - all sum up a task of the greatest difficulty and of enormous labor.*[88]

When they concluded their campaign, the three men had delivered over 150 personal invitations and secured 117 acceptances.[89] More than half the original invitees were German, which upset the French government. French scholars threatened to withdraw from the Congress unless parity could be guaranteed.[90] Newcomb managed to diffuse the situation by allowing French scholars to fill vacated spots as they became available. The organizing team returned across the Atlantic to shift their focus to confirming the American speakers, and to mourn the loss of Frederick Holls, who died in July of 1903. His position on the committee remained unfilled.

The organizers also required an appropriate audience. Letters were sent to prominent

87 Rogers, "History of the Congress," 16-9. Newcomb focused on France, Small was given England, Russia, Italy, and part of Austria, and Münsterberg scouted in Germany, as well as visiting Austria and Switzerland. Due to their different specialties, there was some overlap. Münsterberg's connections were mainly in philosophy, philology, art, education, psychology and medicine. Small looked after politics, law, economics, theology, sociology and religion. Newcomb retained special oversight of the departments of mathematics, physics, astronomy and biology. For further discussion, see Münsterberg, "The Scientific Plan of the Congress," 87-105.

88 *Ibid.*

89 *Ibid.*, 18.

90 Hanzlik, "Education Beyond Borders," 167.

scientific societies, requesting that their annual meetings be set at St. Louis during the week of the Congress (for example, the International Geographic Congress accepted this suggestion). Personal letters were sent to leading academics. In some instances, special invitations were made to lesser-known authorities permitting them to present a ten-minute paper on a subject of their choosing at the end of a session.[91] In addition, general notices were placed in major academic journals, including *Popular Science* and *Science*:

> *The organizers of the Congress, to be held at the Universal Exposition, St. Louis, on September 19-25, 1904, desire to invite the special attention of Professors and men of science in the United States and Canada to the unexampled opportunity which it offers to meet and hear a great number of eminent men of learning. It is expected that more than three hundred eminent scholars of Europe and America will deliver discourses in the various departments and sections of the Congress, and that several hundred short communications will be made by those present.*[92]

Rogers calculated that 7000 people outside of St. Louis came primarily to attend the Congress.[93] Münsterberg estimated that there were between 100 and 200 people in the audience in each of the 128 sectional meetings. For a Congress that the organizers initially feared would not be viable, the ICAS turned out to be a huge event.[94]

The Congress was not truly "universal" in character. Only a select few countries were involved. In terms of nationality, Americans were the majority of the participants, but there is a caveat: these numbers indicate where the participant resided in 1904. When the country of birth is taken into consideration, the pool of delegates is more international. The selection sample nevertheless leans toward the Anglo and German scientific community. The 500 individuals that served as chairs and speakers were the main cohort of participants, and they were the de facto "responders" to the survey. In terms of institutions that were involved, the large American colleges that hosted the event are over-represented. See Figure 2.7 (next page), which shows the ten institutions most heavily represented at the ICAS. The top nine institutions represented were American, and the tenth was the University of Berlin. In Figure 2.8 (next page), a breakdown of all represented institutions is provided, showing how many of the delegates represented American or German institutions. 83% of all ICAS delegates represented American institutions, 9% represented German institutions, and another 7% represented other foreign institutions. The remaining 1%

91 Rogers, "History of the Congress," 20. 250 short papers were promised, and 102 were actually read.

92 N. M. Butler and S. Newcomb, "Invitation to the International Congress of Arts and Science," *Science* 20, no. 505 (1904).

93 Rogers, "History of the Congress," 42.

94 Hugo Münsterberg, "The Scientific Plan of the Congress," 131.

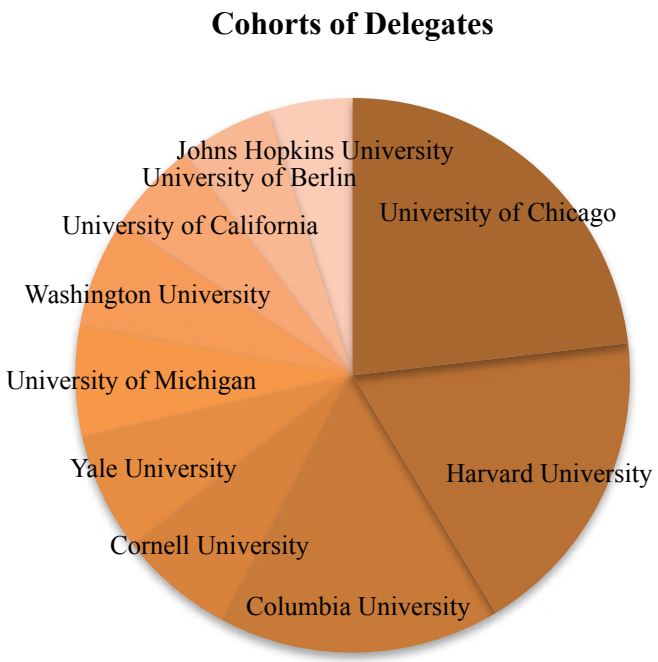

Figure 2.7. Ten Largest Cohorts of Delegates at the ICAS (by Institution)

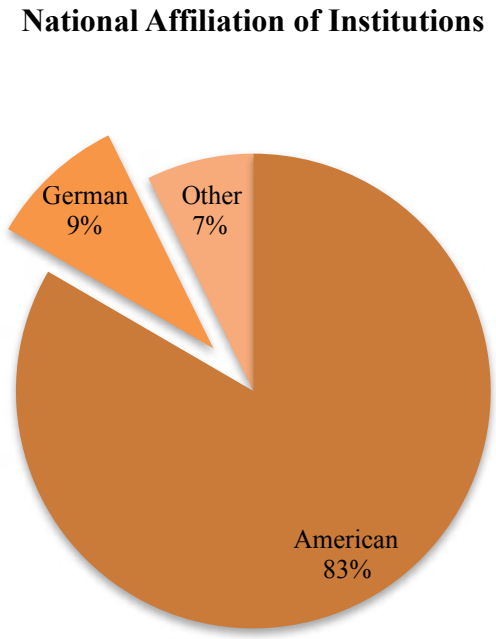

Figure 2.8. National Affiliation of Major Educational Institutions Represented at the ICAS (by Number of Delegates).

The administration's inferred endorsement of the philosophy behind Münsterberg's schematic removed some voices that may have provided valuable insight. Educationist John Dewey, for example, was incensed by the premise that all knowledge could be unified and refused to attend.[95] Other potential speakers were silenced by not being included on the invitation list. Gilbert has discussed in *Whose Fair* how "unity" in St. Louis was achieved by excluding potentially quarrelsome elements, for example since Max Weber spoke, no mention was made of political theorist Vladimir Lenin.[96] All of these absences limit the quality of the proceedings as a survey response, but the proceedings nevertheless provide an unparalleled snapshot of intellectual ferment at the end of the long nineteenth century.

Physical preparations for the Congress began in 1903. Hugo Münsterberg went to St. Louis in January to consult with the Fair authorities.[97] 500 officers and speakers were expected, with 2000 registrants and many more attendees in the audience.[98] The opening exercises were held at Festival Hall, capable of seating 3000 people. Lecture halls were also located in the palaces of education, mines and metallurgy, agriculture, and transportation. Nine new buildings were made available at nearby Washington University, containing lecture halls for up to 1500 people. Larger rooms were assigned to the more popular subjects, but occasionally a great speaker had to be allotted a smaller hall. Generally, the hosts were unable to provide the typical "academic peace and quiet" found at scientific gatherings.[99] Two of the halls proved challenging for speakers because of the Intramural Railway. Münsterberg complained that "the roaring of the Pike overpowered many a quiet session, and the patient speaker had not seldom to fight heroically with a brass band on the next lawn."[100] In the official history, however, Rogers recalled little objection to the room assignments:

> *Every one seemed to recognize the fact that the immediate value of the meeting lay in the commingling and fellowship, and that the addresses, of which one could hear at most only one in sixteen, could not be judged in the proper light until their publication.*[101]

---

95 Scaff, *Max Weber in America* (Massachusetts: Princeton University Press, 2011), 55. The works by John Dewey that he refers to include *Democracy and Education: An Introduction to the Philosophy of Education* (New York: The Macmillan Company, 1916); *The Quest for Certainty: A Study of the Relation of Knowledge and Action* (New York: Minton, Balch, 1929). Scaff contends that Dewey made his contribution in another way when he formulated his own vision of education in opposition to Münsterberg's, one that is evident in his own later publications.

96 Gilbert, *Whose Fair?*, 27.

97 Münsterberg, "The Scientific Plan of the Congress," 101.

98 Hanzlik, "Education Beyond Borders," 167.

99 Rogers, "The History of the Congress," 20.

100 Münsterberg, "The Scientific Plan of the Congress," 128.

101 Rogers, "The History of the Congress," 20.

Over 90% of the guests arrived by way of New York, and the courtesies of the Century and University clubs and special privileges of the Port were extended to each foreign speaker while they remained in the city.[102] Twenty of the speakers were already housed at St. Louis, serving as prize judges, and some of the speakers that came from abroad proceeded directly to St. Louis, but the majority of attendees detoured through Chicago on their way to Missouri, where they were entertained for the week before the Congress by University of Chicago President William Rainey Harper and ICAS Vice-President Albion Small.[103]

American entomologist Leland Ossian Howard of Washington, DC, served as the major on-site coordinator for the whole of September. His long service as Secretary of the American Association for the Advancement of Science (AAAS) prepared him well for this enormous task. In addition, a reception committee derived from the local University Club was formed in St. Louis. They met incoming trains and conducted guests to their accommodations. Foreigners were relieved from all care and expense for rooms and entertainment. Those that brought their families were entertained by prominent St. Louis families. Honorary Vice-President for Great Britain, James Bryce, for example, traveled with his wife and stayed with the mayor of St. Louis. Max and Marianne Weber were housed across the street with German-born financier August Gehner and his wife, Willamina.[104] Those who came singly were quartered in the 96 dormitories of Washington University.[105] In a wonderful example of spin-doctoring from the Gilded Age, press agent Rogers reported in his official history of the Exposition that the dormitory arrangement was "a very happy circumstance," as delegates mingled "much after the fashion of their student days, and thoroughly enjoyed the novelty and fellowship of the plan." In their defense, the dormitories afforded easy access to the Fair, and breakfasts were catered on site.

The reality was that some attendees found the accommodations insufficient. Scottish geographer Hugh Robert Mill, Director of the British Rainfall Organization and Secretary of the Royal Geographical Society, kept a diary that indicated he found his journey to be filled with slight indignities. On board his ship on Sunday, August 28 he wrote "Placed at small table with 1 Yankee youth and 8 typical school marms."[106] The next day he found respite talking to Duncan, a chemical engineer, read Émile Zola's *Fécondité*, and arranged slides for an upcoming lecture on exploration in the Antarctic. After he arrived in Boston, he was herded through tours of Harvard University,

102 Rogers, 21.

103 *Ibid*., 22.

104 Scaff, *Max Weber in America*, 69-70.

105 Rogers, 21.

106 "Daily Doings." HRM 7&8. CB7/M, HR (1881-1910) file. Royal Geographical Society, London. Mill kept a "Daily Doings" journal, a pre-lined notebook that permitted a one-line entry for each day. He took this with him when he set sail on the ship "Devonian" on August 27, 1904 and updated it throughout the trip.

the Boston library, and the Museum of Natural History. He then detoured to Washington, DC, and gave the keynote at the International Geographic Congress, meeting Alexander Graham Bell at the International Geographical Society (IGS) dinner on September 8. Meetings during the day and receptions by night in Washington, Philadelphia, and New York followed. He reported his time in Philadelphia was "strenuous" and at a reception at West Point "all efforts of cadets to lower the flag failed."[107] On September 16, he delivered another speech in Chicago, and two days later he was in St. Louis where he "waited 3 hours at St. Louis Station for guides from Int. Cong. Of Arts and Science and nightmare journey to a dormitory."[108] Years later, he remembered how:

> *A nonchalant individual lounged up, "guessed" we were the Europeans who were expected, and said that we would go straight away to our quarters at Washington University in the Exposition grounds. J.B. Bury, the historian, and I were hustled into an overcrowded tram-car, carrying our luggage, and stood for a half hour through endless streets, then changed to a less crowded car, and finally walked a half mile to unfurnished rooms in a half-finished building, and were shown to a restaurant for our meals. Hour by hour, articles of furniture were dumped in our rooms, but the equipment was not complete until a week later, when we just left as the final bedroom crockery arrived.*[109]

Monday, September 19 was a "dreary day in chaotic Exposition and nearly inaudible address of Congress by S. Newcomb."[110] That appears to have been the low point in his journey. Mill seemed pleased when an expense account materialized on Wednesday, and his ego was mollified when he was seated next to Viscount James Bryce at a grand dinner. He did not become a fan of American trains or the accommodations, and immediately after giving his address, he slipped out of town with a few colleagues and headed west towards Arizona, spending September 26 and 27 at the Grand Canyon. By September 29 he was on a sleeper headed back to the east coast and then to Britain, "rejoicing" on the top deck as he neared home.[111]

Mill's unfortunate experience illustrates the crowded conditions of the Fair, as well as the unacknowledged importance of marrying well for the Victorian professor. An academic career in the newly professionalized sciences required not only intellect, but financial backing, social connections, a public profile, and more than a little luck. The financing may have been derived

---

107 *Ibid*. This was because a patriotic cadet had nailed it to the pole so that foreigners would not see it lowered. See further reminisces from Mill in *Hugh Robert Mill: An Autobiography*, 174.

108 Mill, "Daily Doings."

109 *Ibid*., 175.

110 Mill, "Daily Doings."

111 *Ibid*.

from family wealth, prize monies, or other patronage. The social connections were often based on circles of alumni from prestigious universities and strategic marriages, which might refer to the lady's financial means, but could also include the skill set of a built-in confidante, social companion, and helpmate. Many scientific wives not only assisted with easing social gatherings but also functioned as unpaid laboratory assistants, editors, and / or mapmakers in aid of their husband's careers, as well as providing all the typical homemaking duties a middle-class woman would be expected to contribute. A considerable amount of academics married relatives of professional friends and acquaintances. The social and educational backgrounds of the ladies often proved helpful in being accepted into a professional society, conducting a lengthy field trip, writing for publication, or easing the way during tours for public appearances such as the ICAS. Mill had such a wife, his beloved Isabella, who did not make the trip with him as she had just come down with the measles. If she had, he would have been housed in one of homes of the society wives of St. Louis and both would have been entertained by the Ladies Auxiliary. It was not to be: the men who arrived as singles were sent to the dormitories. Mill was displeased with accommodations, and he opted to escape the Fair as soon as possible. The organizers had secured their funding and mandate, overcome the initial reluctance of the international community to support a Fair in the American West, and launched a formidable campaign entreating European intellectuals to attend the Congress. But in Mill's case, a potential connection was lost due to a simple lack of hospitality. Small details do matter in social networking.

European academics as a whole, especially some of the more refined scholars such as Mill, would likely have been quite shocked by the arrangements in St. Louis. At the Congresses at the Paris exposition in 1900, social classes were deferred to, the various disciplines were separated, several different kinds of membership for each society were recognized, and most of all, the meetings were kept small. The ICAS, by contrast, was set up for the benefit of a new kind of scientific investigator, an individual that may not be from the middle or upper classes but could trace their intellectual genealogy back a century. Many of the academics at the ICAS had been raised in relatively humble circumstances in Western North America or worked in the West at some point in their professional careers. They often had obtained graduate credentials on the eastern seaboard or in Europe, and they definitely kept abreast of the latest scientific developments on both sides of the Atlantic. The Europeans, however, were not as informed about academic work being conducted in North America, although in many cases they were corresponding with individual North American scientists who were working in the same field. The ICAS was intended as a premium opportunity for the eastern and western peripheries of scientific networks to meet. Some maximized the opportunity, others passed it by.

Aspirations

The opening ceremonies were held at the auditorium of Festival Hall. Howard J. Rogers called the meetings to order. Exposition organizers David Francis and Frederick James Volney Skiff provided an overview of the sights on the grounds that the guests could take in. Skiff proclaimed:

> *This universal exposition is a world's university. The Congress constitutes the faculty; the materials on exhibition are the laboratories and the museums; the students are mankind.*[112]

Figure 2.9. Münsterberg and Newcomb presiding at the ICAS, 1904.[113]

The official welcomes were responded to by representatives from each of the contributing countries. Simon Newcomb then gave his address on "The Evolution of the Scientific Investigator." The speech was essentially an overview of major scientific thinkers until the nineteenth century, at which point the work of the Congress was expected to take over. Newcomb expressed optimism that the week of discussion would afford some new contributions:

> *Gentlemen and scholars all! You do not visit our shores to find great collections in which centuries of humanity have given expression on canvas and in marble to the hopes, fears, and aspirations. Nor do you expect institutions and buildings hoary with age. But you feel the vigour latent in the fresh air of these expansive prairies, which has collected the products of human genius by which we are here surrounded, and, I may add, brought us together.*[114]

---

112 Rogers, "The History of the Congress," 28.

113 Missouri History Museum. "Professors Simon Newcomb (1), Munsterberg (2), Waldeyer (3) on stage at a session in Festival Hall at the 1904 World's Fair." Photographer unknown, 1904. ID: N28374. Available online at: http://collections.mohistory.org/resource/148600.html. No known copyright.

114 Simon Newcomb, "The Evolution of the Scientific Investigator," *International Congress of Arts and Science* 1. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 147.

The opening remarks were difficult to hear. Münsterberg recalls that Newcomb's comments were unexpectedly "accentuated by the thunder of the cannons with which Boer and British forces were playing at war nearby."[115] Newcomb intended to implant the notion that science and scientists could evolve in the same manner as the subjects they study.

A week of lectures followed where participants discussed not only organic evolution, but social evolution, the evolution of liberty, historical evolution, economic evolution, methodological evolution, and even "the evolution of the collective psychic products of human communities."[116] American physician Frederic Dennis enthused on the evolution of surgery over the previous century, made possible by "God's infinite mercy.[117] German logician Benno Erdmann indulged in an aside on the theological evolution of the Christian concept of God during his lecture on causal law.[118] Historian William Sloane titled his speech "The Science of History in the Nineteenth Century" and discussed the "evolution of a state, the supreme social unit."[119] These examples are but a small selection and demonstrate that widespread interest in evolution was evident even without including the biology sections: in fact, evolution was introduced as a concept more than eight hundred times during the speeches. Demonstrating evolution or progress within a field, endorsing the use of a scientific approach, and almost as important, achieving public recognition of a field as being "scientific," was vital for the academics who attended. Discussion concerning the physiological evolution of organisms, however, was confined mainly to the biology section.

Münsterberg saw the contributions of the ICAS as four-fold: personal contacts, cross-Atlantic academic alliances; a demonstration of a world congress focused one problem; and finally, unity in science.[120] The congress was synthetic, then, on two levels: in the intellectual work itself, and in improving the relationships between communities of scientists. Connections were made during the scheduled sessions and during the evening receptions and dinners. On Monday, there was a party for the guests that provided musical performances, a tour of the Grand Basin, and a boat rides on the lagoon that was supposed to be accompanied by a light show. Unfortunately, it rained. There was also a banquet for chemists provided by the St. Louis Chemical Society at the

115 Münsterberg, "The Scientific Plan of the Congress," 128.

116 Karl Gotthart Lamprecht, "Historical Development and Present Character of the Science of History," *International Congress of Arts and Science* 3. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 117.

117 Frederic S. Dennis, "The History and Development of Surgery During the Past Century," *International Congress of Arts and Science* 11. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 313.

118 Benno Erdmann, "The Content and Validity of the Causal Law," *International Congress of Arts and Science* 1. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 368.

119 William Milligan Sloane, "The Science of History in the Nineteenth Century," *International Congress of Arts and Science* 3. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 24.

120 Münsterberg, "The Scientific Plan of the Congress," 131.

Southern Hotel. On Tuesday, a general reception was held by the Exposition's Board of Lady Managers, which consisted of society wives in St. Louis. On Wednesday, there was a garden party at the French National Pavilion in the afternoon, with better weather, and then a grand reception in the evening at the German State House. Thursday evening saw a Shaw banquet at the Buckingham Club for foreign delegates (so called because the funds were derived from the will of Henry B. Shaw, founder of the Missouri Botanical Gardens).

After the sessions, participants mingled with academics in other fields at the many social events, but during the day they were effectively hived off into disciplines to pursue highly specialized discussion. On the second day, the twenty-four divisions of knowledge in the twelve rooms in Festival Hall allowed the attendees to take in one alternate session that interested them, but by the next day the increasingly specific discussions kept the various fields engrossed in their own concerns. Despite the intention to unify knowledge, the disciplines were effectively segregated by the end of the second day. On the third day, the celebration of American content simmered down and international work began. 128 sectional meetings were held during the last four days of the Congress. Each section meeting was three hours in length, with two speakers given forty-five minutes each and the remainder allotted for discussion. The first paper in the section was to relate the sub-field to other branches, and the second was to focus on its present problems. Within the life sciences sections, the speakers repeatedly returned to the most pressing issues of the day: natural selection, systematics, changes in nomenclature, and the perceived need for biology to become an observed and measured science.

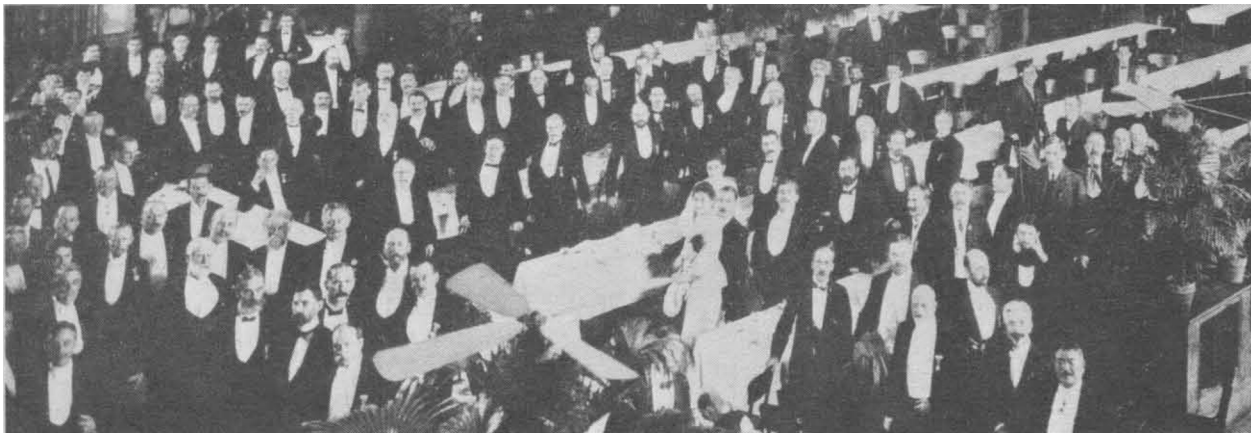

Figure 2.10. Grand reception for the ICAS participants.[121]

121 In Bennitt, *History of the Louisiana Purchase Exposition*, 691. Photograph by William Rau. Public domain.

On September 20, addresses were given on the main divisions of science and its applications, with the general themes being on unification of each of the fields treated. Opening remarks by leading American academics were followed by two addresses on each of the twenty-four departments of knowledge. The theme of the first of these addresses was to be on methodology, and was typically given to the American speaker, while the second speaker was to discuss the progress in the field over the last century, which the organizers preferred to allot to the European academics. Therefore, the work of the first two days was primarily American content. The designations were somewhat deceiving, however, as the "American" group included foreign-born Americans and all the Canadians as domestic academics. In Figure 2.11 (next page), the country of birth and country of residence for all delegates has been charted. Each point in the circle represents a delegate. The connecting lines indicate wherever a delegate was born in one nation and migrated to another (usually moving from Europe to the USA as an adult). The data is derived from the speaker list of the proceedings (a complete list of speakers and the institutions they represented is available in Appendix A). When looking at the country of birth for all delegates, it is clear that the American cohort may be better characterized as multicultural. Despite the nationalistic rhetoric of the participating countries, science was an international endeavor.

Münsterberg bristled at criticisms of the program and what he perceived as defects or deviations from the plan: "the principal difficulty has been that many speakers have not really treated the topic for the discussion of which they were invited."[122] He had created a detailed idealistic explanation for the division of the sciences as presented in the program, yet certain speakers chose to use the Fair platform to discuss some particular issue that interested them. Any deviations infuriated Münsterberg, who was essentially conducting a survey. The proceedings indicate, however, that the majority of speakers did comment on the development of their discipline, and/or a briefing on present, pressing problems. Certainly enough speakers complied that historians of science today can gleam some generalities on how scientists saw the significance of their work in 1904. The ICAS organizers faced a number of challenges in their attempt to unify knowledge: an unfavorable location, the dominance of European and especially German academics, the exclusion of some competing schools of thought, the reservations of pragmatists about the schedule, and the reluctance of foreign governments to commit resources. Despite all these challenges, the proceedings of the ICAS remain one of the best sources to investigate how the practice of life science was changing at the turn of the twentieth century.

122 Münsterberg, "The Scientific Plan of the Congress," 128.

Figure 2.11. Migration patterns of the ICAS delegates.

Department Thirteen

The biology section, Department Thirteen in the proceedings, produced discussions that revolved around theories of evolution, and different types of biological experiments in the field and in the laboratory. Biologists at the ICAS were for the most part focused on debating the virtues of the field versus the lab, and sidestepped the controversy over Münsterberg's program by simply ignoring what they perceived as arbitrary divisions separating the fields within life science. As a group, they had fairly diverse backgrounds in terms of disciplines and they were willing to travel widely for their studies. This was consistent for how life science operated throughout the nineteenth century: the most spectacular advances in biology had always occurred in an open social environment, one that embraced interdisciplinarity and cross-cultural contact, and circumvented distinctions between academic, amateur, and lay reader.

The chairman for biology department at the ICAS was William Gilson Farlow, who spoke in general terms about the potential of the discipline on the first day and then gave up the floor to botanist John Merle Coulter of the University of Chicago and zoologist Jacques Loeb of the University of California. The two eminent biologists discussed the progress of biology since 1903, with Loeb endorsing laboratory study and Coulter defending field science. *Popular Science* magazine reported that over the week of lectures, the roster for the various biology sections was filled with "eminent men" from abroad, although the most public interest was focused on the phytogeny section, which was chaired by evolutionary biologist Thomas Hunt Morgan and featured his close colleagues geneticist Hugo de Vries and zoologist Charles Otis Whitman.[123]

Loeb promoted the phytogeny section during the keynote session on biology.[124] He argued that biological investigations should analyze "a special class of machines," which were living organisms, a class he described as consisting of colloidal material that could develop, preserve and reproduce themselves automatically.[125] He asserted that chemical processes in inanimate and living matter are identical, and chemical biology is therefore capable of predicting its results quantitatively. Loeb was utterly intent on forcing biology to be a hard science on the model of physics and chemistry. Acknowledging the great merit of English naturalist Charles Darwin in initiating studies on evolution, Loeb nevertheless found it truly "remarkable that none of the

123 William Harper Davis, "The International Congress of Arts and Science," 26. Davis was also a speaker in the earth sciences section.

124 Loeb was a graduate of the *Ascanisches Gymnasium* in Berlin, he had obtained his MD from Strasbourg, and then he was immediately recruited by the University of Würzburg in 1886. He took on research work for the Biological Station at Naples in 1889 and relocated to the USA in 1891. He spent a year as an Associate Professor in Biology at Bryn Mawr, and then stayed ten years at the University of Chicago. In 1902, he was recruited by the University of California. If most of the scientists at the ICAS represented the elite in their field, Loeb was royalty.

125 Jacques Loeb, "The Recent Development of Biology," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers. (St. Louis: University Alliance, 1908), 13-4.

Darwinian authors seemed to consider it necessary that the transformation of the species should be the object of direct observation."[126] His tone was mocking as he pointed out that although the general understanding in the natural sciences was to use direct observation and mathematics to form the basis of conclusions, "this rule was considered superfluous by those writing on the hypothesis of evolution."[127] At the Fair, Loeb credited German naturalist Gregor Mendel with providing one of the most important papers ever published in biology on the *Hybrids of Plants*.[128] Mendel did most of his work with peas and managed to publish the results in a local journal, and he attempted to confirm some of his material by breeding bees later in life.[129] His theory of heredity went unnoticed, however, until three European scientists, Hugo de Vries, Carl Correns, and Erich von Tschermak, discovered the same facts anew in 1900 and subsequently became aware of Mendel's work.[130] In his speech Loeb cited only his associate, de Vries. He claimed that the work of fellow speaker de Vries marked "the beginning of a real theory of heredity and evolution."[131] He congratulated de Vries for proposing that "mutations" could be directly observed in certain groups of organisms, and for moving evolutionists away from the more polemic literature of the mid-nineteenth century. He anticipated a time in the near future when scientific advances would bring about as thorough a revolution in ethics as they had wrought in material life, and expected that the struggle against religiosity would be entirely carried on by the natural sciences.[132] "Lourdes and Mecca are in no danger from the side of the representative of the mental sciences." he scoffed,

126 *Ibid*., 17.

127 *Ibid*.

128 *Ibid*. It is well known that the paper was not actually prominent within Mendel's own lifetime. Historian Peter J. Bowler has written extensively on Mendel's life as well as on the impact of Mendelian genetics after the turn of the twentieth century. The Austrian monk had discovered that certain characteristics were present in the germ as definite determinants. He showed that in the process of creating hybrids, one half of the sexual cells of each child contained the determinants of one parent, while the other half contained the determinants of the other parent. See Peter J. Bowler, *The Mendelian Revolution* (Baltimore: The Johns Hopkins University Press, 1989), esp. 99-105.

129 Robin Marantz Henig, *The Monk in the Garden: The Lost and Found Genius of Gregor Mendel, the Father of Genetics* (Boston: Houghton Mifflin, 2000), 120.

130 Another co-discoverer of Mendel was also present on the LPE grounds that day, although he was not a part of the ICAS or Loeb's immediate circle. William Jasper Spillman, formerly a professor in Oregon, had reproduced Mendel's conclusions doing an experiment with wheat varieties. Unlike the fate of the European re-discoverers, who continued to work in academic institutions, Spillman was immediately recruited by the United States Department of Agriculture (USDA). He was working in the horticultural exhibits at the Fair that summer. Several years later, he would found the new discipline of agricultural economics. See Laurie M. Carlson, *William J. Spillman and the Birth of Agricultural Economics* (Missouri: University of Missouri, 2005), 13-21.

131 Loeb, "The Recent Development of Biology," 17.

132 *Ibid*., 23.

"Superstition persists only because the masses are not taught science."[133] He continued, "the wealth of modern nations, of Germany and France, is not due to their statesmen or to their wars, but to the accomplishments of the scientists."[134] As such, he suggested that experimental biology should be differentiated from the rest of life science as an independent science, and represented in universities by special chairs and laboratories. He envisioned the task of experimental biologists as the analysis and control of living organisms, including their development, self-preservation, and reproduction.[135] Field biologists would find themselves on the defensive during these sessions.

Delegates in Department Thirteen spent most of their time in formal discussions but were also able to witness numerous practical demonstrations. Model farms and methods of crop improvement were featured throughout the grounds. The exhibits on agriculture that the LPE organizers offered were especially relevant to life scientists at the ICAS, as many of them had been involved in biological research with practical applications. American botanist William Gilson Farlow had previously published papers on potato rot, grape mildew, onion smut, and fungous diseases. French zoologist Alfred Giard focused on phylogeny in his speech but had previously published on agronomy, overfishing, and the possible use of parasites to biologically castrate insects. Even those participants that had not been directly involved in applied science recognized its importance (and completely negated the organizing committee's extensive debates on "pure" versus "applied" science). When looking at the advances of the previous century, the speakers included the work on soil improvement conducted by chemist Justis von Liebig and the practical applications of Louis Pasteur's laboratory studies.[136] The group was aware that the line between studying relationships between organisms in nature and studying relationships between organisms managed by humans was exceedingly thin. Most overtly, ecologist Oscar Drude commented during his lecture that "agriculture could be considered a branch of ecology, which long preceded methodical science."[137] Drude was deeply involved with the agricultural experiment stations in Germany, serving as Director of both the Botanical Garden and the Experiment Station at Dresden.

133 *Ibid*., 22.

134 *Ibid*., 23.

135 *Ibid*., 24.

136 Liebig had established the "law of the minimum" regarding the relationship between soil minerals and plant growth. See Gregory John Cooper, *The Science of the Struggle for Existence: On the Foundations of Ecology* (Cambridge, United Kingdom: Cambridge University Press, 2003), 32. See also Julius Wiesner, "The Development of Plant Physiology under the Influence of the Other Sciences," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908), 110.

137 Oscar Drude, "The Position of Ecology in Modern Science" *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908), 190.

The life sciences were not only a model of interdisciplinarity; they also showed a consistent trend of expansion and growth. President Newcomb had hoped that by promoting unification of knowledge at the ICAS, opportunities in new educational streams would appear through "combinations of effort on the part of its votaries."[138] His thoughts were prescient, since new sub-fields such as vegetable pathology and agricultural economics would appear in colleges within a few years. Historian Alexander Vucinich has summarized the intellectual landscape within biology at the time as a "vast enterprise of evolutionary inquiry" with three especially strong interests: the evolution of species, the evolution of embryonic growth, and the evolutionary role of the environment. Vucinich argues that the latter gave new direction to biogeography and ecology. Yet biogeography was not treated as a field within the life or earth sciences based on the text of the proceedings: not even the terminology had been settled for the purposes of the ICAS.[139] The term "biogeography" was used by German physiographer Albrecht Penck, who brought up the subject only long enough to define it as the distribution of biological forms and provide it as a contrast to physical geography.[140] It was referred to as "ontography" by American geographers William Morris Davis and Thomas Chrowder Chamberlin, and Chamberlin did not go into any detail at all, merely commenting that there was need for more attention to the subject.[141] At the ICAS, there was far more awareness of ecology than biogeography.

---

138 Simon Newcomb, "The Evolution of the Scientific Investigator," 147.

139 Alexander Vucinich, *Darwin in Russian Thought* (Berkeley: University of California, 1988), 373.

140 Albrecht Penck, "The Relations of Physiography to the Other Sciences" *International Congress of Arts and Science* 8. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908), 609. Like ecology, the field of biogeography has struggled with issues related to scope, professionalization and modernity. Biogeographer Brent Riddle has commented on the extended "identity crisis" his field suffered during its development. He has attacked dubious claims to "modernity," criticizing studies that describe the observations of Alfred Russel Wallace as being thoroughly "modern" (lacking only the foundation of plate tectonics) by pointing out that the views of Joseph Dalton Hooker on floristic histories across continents could also be said to completely "modern" by these standards. He recounts that after Wallace, separate research programs emerged based on Alphonse de Candolle's division of biogeography into "ecological" and "historical" branches. Within ecological biogeography, island studies were favored because they offered the possibility of testable predictions based on a dynamic interaction between colonization and extinction rates. Riddles argues this focus was not "modern," and instead, historical biogeography became the branch that transformed itself, and then only after geologists resurrected the theory of continental drift and appended a model of plate tectonics. His point is that the geological advancements were necessary for the theories to move forward. See Brett R. Riddle, "Is Biogeography Emerging from Its Identity Crisis?," *Journal of Biogeography* 32, no. 2 (2005), 185. The study on Wallace he cites is V.A. Funk, 2004, "Revolutions in Historical Biogeography" in *Foundations of Biogeography*, ed by M.V. Lomolino, D.F. Sax and J.H. Brown, 647-657.

141 William Morris Davies, "The Relations of the Earth-Sciences in View of Their Progress in the Nineteenth Century," 496; Thomas Chrowder Chamberlin, "The Methods of the Earth Sciences" *International Congress of Arts and Science* 8. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908).

Munsterberg had recognized ecology as an established field within life science and provided ecology with its own section at the ICAS. There was also evidence of ecological thinking in many of the biology sections, some of the earth science sections, and even some of the anthropology and history sections. The diversity in ecological thinkers reflects their well-rounded educations and their eclectic interests. Geography and ecology tended to overlap in subject and approach. Anthropologists often had training in biology during their college years. Historians and biologists were slowly incorporating one another's methodology: historical thinking was introduced to biology and geology near the beginning of the nineteenth century, and scientific history became trendy by the 1850s. Interest in studying humans as part of nature, from either the ecological or the historical perspective, had not yet arisen but an integrated approach would become commonplace by the end of the twentieth century. The early ecology network, like the subject itself, demonstrated diversity and a high degree of interconnection.

CHAPTER THREE

1804: THE ORIGINS OF ECOLOGY

In 1903, Oscar Drude, chair of botany for the *Königlich-Sächsisches Polytechnikum*[1] in Germany, accepted an invitation to speak at the International Congress of Arts and Science (ICAS), a high-profile international academic event that sought to "unify all knowledge."[2] In his speech, Drude described ecology as any investigation into the vital phenomena exhibited by plants and animals in the struggle for space, under conditions provided by the climate and physiography of a country.[3] The kernel of his definition is the "struggle for space," which Drude based on the work of German geographer and ethnographer, Friedrich Ratzel.[4] Ratzel proposed the biological habitat of humans might be expressed in geographical or political units, a notion inspired by some of the content found in English naturalist Charles Darwin's *The Origin of Species*.[5] "Each organism is closely associated with its environment," Drude lectured, and "each plant, each animal, lives, like mankind, in a special world of its own."[6] As such, ecology was a new field that existed in the borderland between biology and geography. Drude claimed that in the "struggle for space" each organism strove to secure nourishment and leave descendants. He mused on how each organism had to use available resources and seek out "his" career, creating a parallel between the subjects being studied and the challenge ecologists faced carving out a place in professional science.

---

1 The Royal Saxon Polytechnic Institute had been established in 1828 to educate skilled workers in mechanical engineering and ship construction, but by the end of the 19th century it had developed into a university covering all major disciplines. It is known today as the Dresden University of Technology, one of the top institutions of learning in Germany.

2 Nicholas Murray Butler and Simon Newcomb, "Invitation to the International Congress of Arts and Science." *Science* 20, no. 505 (1904), 317.

3 Oscar Drude, "The Position of Ecology in Modern Science." *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 179.

4 *Ibid*. As a young man, Friedrich Ratzel was heavily influenced by Charles Darwin, German zoologist Ernst Heinrich Haeckel (1834-1919), and a tour of North and South America he undertook in 1874. He became interested in human migration and human use of the environment, and created the concept of *Lebensraum* ("living space") which was reinterpreted by the Swedish political scientist Rudolf Kjellén and later appropriated by the Nazi regime in Germany. For disambiguation between Ratzelian *Lebensraum* and the Nazi political doctrine, see Carl Abrahamsson, "On the Genealogy of *Lebensraum*," *Geographica Helvetica* 68 (2013). See also Sander Gliboff, *H.G. Bronn, Ernst Haeckel, and the Origins of German Darwinism: A Study in Translation and Transformation* (Cambridge, Mass.: MIT Press, 2008). Gliboff is sharply critical of historiography that links any kind of aberrant German evolutionism to "the worst biology-based political ideologies of the twentieth century." (Gliboff, 6).

5 Charles Darwin, *On the Origin of Species by Means of Natural Selection: Or, the Preservation of Favoured Races in the Struggle for Life* (London: John Murray, 1859). It was translated into German several months later.

6 Drude, "The Position of Ecology," 179.

Modern Ecology?

At the ICAS, ecology was allotted its own section. The ecologists who participated were botanists, orthodox Darwinists, and focused on field studies. Drude had previously produced a textbook on plant geography that left a deep impression on the American grassland ecologist who was serving as secretary for the session, Frederic Edward Clements.[7] According to historian Ronald Tobey, Drude's writings provided the young westerner with a new perspective on the prairies and set him on his path in professional ecology.[8] Both Drude and his fellow speaker, American botanist Benjamin Lincoln Robinson, recognized the contributions of field biologists of previous generations, and lobbied for administrative and financial support for the maintenance and development of natural history collections.

Ecologists were going against the current whenever they advocated for more, and better, field studies. The common wisdom in higher education at the time was that laboratory studies were preferable to field studies, as biologist Jacques Loeb had vehemently argued in the opening speeches. In the context of life science that meant investigations into mutations were more exciting since they promised the possibility of witnessing evolution jumping forward in a controlled environment. Regardless of the hype surrounding experimental biology, ICAS vice-president Hugo Münsterberg and his planning committee had provided a full section for ecology, making the ICAS the first major international congress to include ecology as an individual field.

The language used in the ecology section contradicted the address provided by Loeb. The keynote, Drude, explained the relationship between ecology and the other branches of science. His counterpart, Robinson, argued that contemporary ecologists presented plants in their "most human aspect" by dealing with their struggles to obtain room, light and food within their own environment.[9] The theme of struggle against considerable odds echoed the adversarial language adopted by English biologists Charles Darwin, Thomas Henry Huxley and Herbert Spencer in the 1860s.[10] There were numerous examples of ecologists operating with that perspective, as Robinson reminded his audience when he quoted Danish botanist Eugene Warming's suggestion that the

---

7 Clements wrote, years later, to Drude: "You will recall that I obtained my first clear view of our field through your *Deutschlands Pflanzengeographie* and have always remained under obligation to you for this and your other stimulating works." As quoted in Ronald C. Tobey, *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895-1955* (Berkeley: University of California Press, 1981), 87–88. The text he referring to is Drude's *Deutschlands Pflanzengeographie: Ein Geographisches Charakterbild Der Flora von Deutschland Und Den Angrehzenden Alwen-Sowie Karpathenlandern* (Stuttgart: J.Engelhorn, 1896).

8 Tobey, *Saving the Prairies*, 60.

9 Benjamin Lincoln Robinson, "The Problems of Ecology." *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908), 194.

10 Iain McCalman, *Darwin's Armada: Four Voyages and the Battle for the Theory of Evolution* (New York: W.W. Norton & Co. ebook, 2009), 643.

most attractive inquiry in the study of plants may be to investigate the "weapons" they use to force one another from specific territory. Robinson mitigated Warming's militaristic metaphor, however, by questioning whether it might be more useful to focus on the relative vulnerability of plants. Only then could ecologists determine what kind of artificial interference was most appropriate.[11] Such an approach would be scientifically sound, and could lend itself to useful information for agriculturalists and horticulturists.[12] Robinson was already considering a kind of applied ecology that would include human management as a component.

Robinson associated ecology with botany, agriculture, and geography. He recognized that the ecology of plants looked at the relations of plants to their inorganic environment, but believed the best basis for grouping ecological facts remained their geographic aspect. Thus there was considerable crossover with plant geography. Like Drude, he indicated that much of what was categorized as agriculture, horticulture, and forestry could be considered a form of experimental ecology but he felt that in "practical" studies the scientific aspect was obscured by the economic.[13] He did not draw a specific line between the domesticated landscape and the wilderness, but it was nonetheless implied. He cited numerous examples of leading edge, field-based ecology. Studies had been performed In Minnesota by the chairman of his session, American botanist William Gilson Farlow. Drude had conducted phytogeographical studies that showed evidence of ecological thinking in Germany. Eugenius Warming had similarly investigated tropical plant formations along with his German colleagues, Franz Schimper and Karl Goebel. Ecological studies on the grasslands had been produced by Frederic Clements in Nebraska with his research partner, Roscoe Pound. Robinson cautioned that vast areas had yet to be studied from the ecological viewpoint, both to the south, in the "boundless floral wealth" of Mexico, and to the north in "the great expanse of British America, readily accessible, healthful in climate, with a rich flora, taxonomically well explored and recorded by an indefatigable government naturalist, but offering for the most part virgin soil to the ecologist."[14]

Robinson saw the potential for ecology not as an opponent of experimental biology, but rather as a bridge between theoretical and applied botany, essentially philosophical in many aspects but nevertheless a useful and progressive approach with a rich tradition.[15] He thought ecology had great prospects to contribute to human welfare. It did not seem to occur to him that scientific ecology would also someday become a necessary part of mitigating human impact on the

11 Robinson, "The Problems of Ecology," 202.

12 *Ibid*., 203.

13 *Ibid*., 201-02.

14 *Ibid*., 198.

15 *Ibid*., 203.

environment. Yet within a few short decades, anthropogenic harm would be assumed and the study of humanity and the environment would no longer be conducted in separate spheres. The synthesis of ecological and historical thought would lead to a new kind of ecological practice that merged science and ethics. Ecologists practicing in 1904 are located in the gap between the evolutionists of the Gilded Age and the self-consciously ethical ecologists of the twentieth century. Robinson chided his fellow botanists to acknowledge their own history, clean up any taxonomic carelessness, and carry on in a steadfast manner, despite current pressures to drag their studies indoors. Ecology and field study were inseparable.

Oscar Drude made the distinction between ecology and other scientific fields straightforward. Geographers focused on defining zones and providing descriptions of distinct features of the earth, whereas ecologists were concerned with cause. Reducing masses of data into something comprehensible, Drude claimed that ecologists study "epharmony in the organic world."[16] Ecological thinking balanced morphological aspects with physiographic and phylogenetic aspects. He considered the three aspects of an organism inseparable, and their unification to constitute the essence of both the organism and ecology itself. Ecology and evolutionary theory were therefore inseparable.[17]

Drude argued that ecology at the turn of the twentieth century required advanced equipment, including photometric and thermometric instruments. He instructed students to seek broad training in the life sciences as well as developing "absolute dominion over lifeless nature" because a practicing ecologist had to be proficient in a variety of settings, from the botanist's herbarium to the physiologist's laboratory. Ecologists had to be versatile biologists, all the while bearing in mind the geological development for the area being studied.[18] Ecologists focused on new questions, such as the continuance of an organism in a given location, the power required for it to obtain nourishment, and the need for it to establish succession. For Drude, the ecologist was always "haunted" by the question of vegetation form, and sought to understand how plant formations suited their district.[19] After outlining all the requirements for ecological practice, Drude summarized recent investigations that demonstrated ecological thinking, such as studies

16 Drude, "The Position of Ecology," 184. Epharmony refers to harmonic relation between structure and environment. The term comes from the French and indicates the immediate acquirement by an organism of a morphological or physical alteration that enabled it to exist in an altered environment.

17 John Kricher, *The Balance of Nature: Ecology's Enduring Myth* (New Jersey: Princeton University Press, 2009), 97.

18 Drude, "The Position of Ecology," 179.

19 *Ibid*., 187.

of discontinuous species that appeared in European, North American, and East Asiatic floras.[20] He also expressed interest in studies on the reduction of the number of species inhabiting a limited area–what twenty-first century biologists recognize as monitoring the decline in biodiversity.

Drude titled his lecture "The Position of Ecology in Modern Science." The word "modern" is invoked in everyday usage to suggest that something new is being presented or that it is currently in style, although the concept of modernity specifically refers to a break from the past.[21] Drude's references to modernity, which occur both in the title of his speech and in his discussion of the field, are typical of the speeches at the ICAS, where "modern," "evolution" and "progress" were treated virtually as synonyms. If Drude's presentation had been an isolated example of ecology and modernity being paired, it could be easily dismissed. But that was not the case: many histories of ecology draw an imaginary line where "modern" ecology begins, and since this marker varies by more than a century, the phrase requires further investigation.

Environmental sociologists John Bellamy Foster and Brett Clark insisted that ecology did not exist as a professional field prior to the twentieth century. They contended that early ecology was dominated by a single scientific paradigm, the "idealistic, teleological ontology of vegetation" proposed by American biologist Frederic Clements.[22] English biologist Arthur Tansley similarly claimed that the appearance of "modern" ecology in Britain coincided with the arrival of the twentieth century, although he acknowledged that pioneer work was begun in the 1890s.[23] Tansley's proposal was sensible, since it indicated that "modern" ecologists like Drude and Clements were convening at St. Louis. Although Tansley argued that ecology was not really practiced in England until after 1900 (except in the work of Darwin), he acknowledged that the intellectual foundations for ecology were laid decades before on the continent by phytogeographers like Drude.[24]

---

20 *Ibid*., 189. Drude used *Sorbus Americanus* as his example, but this kind of comparison goes back at least as far as Darwin and his circle. In America, Harvard botanist Asa Gray used an example of discontinuous species present in the United States and Japan to support Darwin's theory of natural selection during a debate with Louis Agassiz in 1859. See A. Hunter Dupree, "The First Darwinian Debate in America: Gray Versus Agassiz." *Daedalus: Proceedings of the American Academy of Arts and Sciences* 88, no. 3 (1959), 562.

21 For a discussion of the use and meaning of modernity, see Konrad Hugo Jarausch, *Out of Ashes: A New History of Europe in the Twentieth Century* (New Jersey: Princeton University Press, 2015), 3-6.

22 John Bellamy Foster and Brett Clark, "The Sociology of Ecology," *Organization & Environment* 21, no. 3 (2008): 326. Referring to Frederic E. Clements, *Research Methods in Ecology* (Lincoln: University of Nebraska, 1905). Clements' methods were heavily influenced by the publications of Drude, and Drude's innovative methods in plant geography arose from his partnership with the German cartographic publishers *Perthes Verlag*. It is not clear why the younger scientist should be preferred as a "launch" point, although Clements' move towards quantified over qualitative data seems to be a factor.

23 Arthur Tansley, "The Early History of Modern Plant Ecology in Britain," *The Journal of Ecology* 35, no. 1/2 (1947), 130.

24 *Ibid*., 130-4.

Arthur Tansley, often considered a pioneer ecologist in his own right, believed that the "modern" practice of ecology was established when Danish biologist Eugenius Warming published *Oecology of Plants: An Introduction to the Study of Plant Communities* in 1895.[25] Historian Peter J. Bowler similarly called Warming the founder of plant ecology.[26] Bowler described Warming's approach as an alternative both to pure physiology and to the traditional focus of most botanists on classification, instead focusing on how the physical conditions of an area determined which plants could thrive.[27] He also realized that there was a network of interactions between the plants that were characteristic of a particular environment. Warming's book was translated in 1896 and it was subsequently widely read in England and America, directly contributing to a tendency to downplay taxonomy and stimulate fieldwork.

The older narrative of the "rise" of scientific ecology in universities has recently been displaced by the idea that ecology is not *only* scientific but is also social and philosophical. In this view, today's ecology is not seen as modern, but as a culmination. Historian Colin Riordan's study of ecology looked for ecological thought in nineteenth-century western Europe.[28] First, he presumed from the outset that the study of nature is always anthropocentric: he was not looking at scientific ecology which purported to study nature on its own terms. Since a history of "nature in itself" cannot be written, and since ecological ideas "aim to change the human condition," he considers them to be essentially political."[29] Riordan created a distinction between so called "green" ideas, which he assigned to environmentalism, and "ecologism," where adherents embraced science but at the same time advocated for a radical restructuring of society.[30] Where there was active protest, Riordan saw environmentalism. Riordan's ecologism, on the other hand, was holistic, prescriptive and apocalyptic, with varying infusions of misanthropy and mysticism:

> *Ecologism is beset with the paradox that it simultaneously needs science in order to provide a sound basis for a critique of the effect of industrialism on the environment,*

25 Originally published as *Plantesamfund - Grundtræk af den økologiske Plantegeografi* (Copenhagen: Philpsen, 1895).

26 Peter J. Bowler and Iwan Rhys Morus, *Making Modern Science: A Historical Survey* (Chicago: University of Chicago, 2005), 223.

27 *Ibid*. The initial translation was into German; Warming's book was not translated into English until 1909.

28 His line of inquiry also has similarities to historian Anna Bramwell's discussions of twentieth century ecology in that neither makes any attempt to separate the political from the academic. See Anna Bramwell, *Ecology in the 20th Century: A History* (New Haven: Yale University, 1989).

29 Colin Riordan, *Green Thought in German Culture: Historical and Contemporary Perspectives* (Cardiff: University of Wales, 1997), 4.

30 *Ibid*., 4. Riordan points to the 1980s debate in Germany between *Realos* (realists) and *Fundis* (fundamentalists), which was new in Germany.

but wishes to reject, restrict, or, at best, radically reform science in its technological manifestation precisely because of the destructive effects of technology.[31]

He discussed rhetorical objections to human interference in the natural environment (such as deforestation and river channeling) and found it indicated "a hitherto unsuspected level" of early ecological awareness, but decided it did not constitute environmentalism "in the modern sense."[32]

Bowler and Morus, Riordan, and Tansley associated ecology with professionalized science in the twentieth century, but when Oscar Drude was asked to reflect on how ecological practice had developed since the time of the Louisiana Purchase, he adamantly argued that ecology was new in name only because ecological thought had been developing for more than a century. He divided the history of the discipline into five periods, and identified a major publication that represented each phase. The five periods can be further simplified into three stages: a beginning period that extended from Linnaeus to Humboldt; a central stage that featured the work of continental academics like August Grisebach and Hanns Reiter but was dominated by Charles Darwin; and recent work (from Drude's perspective) that began with Eugenius Warming. The first stage will be explored in this chapter, and the remaining stages will be discussed over the next two chapters.

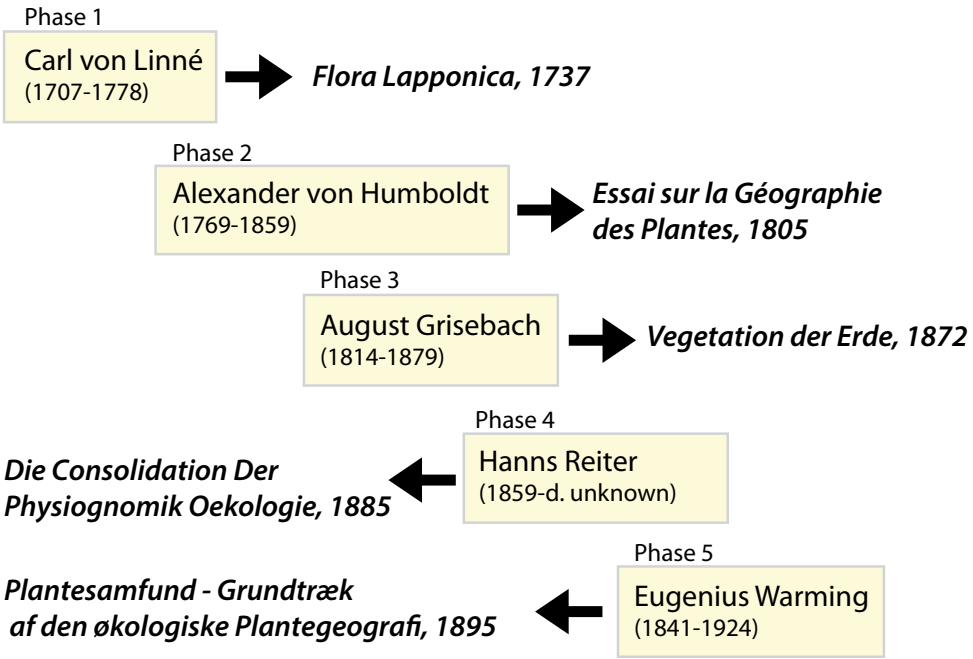

Figure 3.1. The five phases of early ecology. Based on botanist Oscar Drude's schematic for the development of scientific ecology.

31 *Ibid*., 6.

32 *Ibid*.

Drude's first period was initiated by the appearance of a descriptive system devised by Carl von Linné. Generally known by his latinized name, Linnaeus, the Swedish botanist referred to the "economy of nature" in a 1749 publication and argued for the existence of a "balance of nature" where every species made a distinct contribution.[33] Bowler noted that Linnaeus was interested in ecological relationships between species insofar as he acknowledged that should one species increase its numbers due to favorable conditions, its predators would also increase and tend to restore equilibrium.[34] Ecologist John Kricher agreed that Linnaeus grasped the essential ecological context for functioning organisms, one that included the total assemblage of organisms *plus* the climate.[35] Drude's appreciation for Linnaeus, however, was based on recognition that "the appearance of similar associations followed definite laws" and this understanding led to him creating specific vocabulary for analyzing the relationship between organisms.[36] Linnaeus established basic taxonomy rules and provided categories that were defined by common morphological characteristics. Drude credited Linnaeus and his generation as founders of the doctrine of plant formations because of their interest in terminology.

Drude's discussion resembled a discussion from historian Phillip R. Sloan, who claimed that the classification of organisms was a "question" that marked a pivotal point in the history of life science.[37] Although most science develops in small steps and is conducted cooperatively, Sloan suggested that classification was closely tied into the historicization of biology and together they constituted one of the few examples of genuine and sudden leaps forward in life science.[38] Drude and Sloan both recognized Linnaeus as a major contributor, but Sloan provided additional context: whereas Drude only identified Linnaeus' contribution, Sloan focused on the definition of species was clarified during a debate between Linnaeus and French natural philosopher Louis Buffon.

---

33 Drude, "The Position of Ecology in Modern Science." 180. See also Kricher, *The Balance of Nature*, 46.

34 Peter J. Bowler, *Evolution, the History of an Idea* (Berkeley: University of California, 1984), 67.

35 Kricher, *The Balance of Nature*, 45-6.

36 Drude, "The Position of Ecology in Modern Science," 180.

37 Phillip Reid Sloan, "Buffon, German Biology, and the Historical Interpretation of Biological Species," *The British Journal for the History of Science* 12 No. 2 (1979), 109-110. The terms discussion, question, and issue are used interchangeably by Sloan and essentially indicate research programs.

38 *Ibid*. There was a long-term trend within the history of science to emphasize the contributions of specific individuals and discoveries, often in the manner of a heroic tale. The overall norm in the production of scientific knowledge, however, has been steady, slow accumulation and cooperation between various scientists and scientific groups. This is a major theme discussed in Bowler and Morus, *Making Modern Science*. For specific examples see Jan Golinski, especially his discussion of management practices in Justus Liebig's laboratory in *Making Natural Knowledge: Constructivism and the History of Science* (Chicago: University of Chicago, 2005), 73-5; Ernst Mayr similarly discusses the cooperative atmosphere in Thomas Hunt Morgan's laboratory in *The Growth of Biological Thought* (Cambridge, Mass: Harvard University Press, 1982), 753-63.

In 1749, Buffon criticized the taxonomy of Linnaeus, proposing to replace it with a physical network of historical filiation where the "species" would function as the prime example within a successional series.[39] Buffon's understanding of "variety" differed from Linnaeus' accidental characteristics in a fundamental manner. He saw degenerative change occurring in response to environmental conditions:

> *Climate influences the form of animals in such a prominent way that their effects cannot be doubted; and although these [effects] would be less rapid, apparent and sensible on man, we must conclude, by analogy, that these effects are found in the human species, and that they manifest themselves by the varieties that are found there.*[40]

Because Buffon's understanding of species involved adaptation, the classification question was significant to the history of ecology. Sloan discussed two assumptions that made Buffon's reorientation of taxonomy difficult for his colleagues to embrace: the general acceptance that organic entities originated at the first foundation of the world; and a pervasive reluctance to accept knowledge that reached from the present into the past. Essentially, the epistemological status of academic work, whether human history, cosmology, or biology, was considered suspicious if the authority cited was a contemporary.[41] As a result, decades later Darwin's circle was able to examine their "species question" using a common vocabulary: terms included species, race, degeneration, variety, local kind, and nature-description.[42] Sloan claimed that without establishing these concepts, studies on the relationships between organisms would be limited and even nonsensical.

The appearance of historical thinking in biology and the availability of more precise terminology were both important to the origins of ecology, but ecological thinking has also been identified outside the realm of the natural philosophy during this period. In *The Philosophy of Ecology*, philosopher David Keller and zoologist Frank Golley argued that ecology posed metaphysical, epistemic, and moral problems about the concept of nature and the place of humans in the global ecosystem.[43] In their view, studies on the roots of ecology must reach past Linnaeus, Buffon, and Kant. They identified ecological thinking in the writings of Jean Jacques Rousseau,

---

39 Sloan, "Buffon, German Biology, and the Historical Interpretation of Biological Species," 117. Sloan has translated the original quotation in French.

40 *Ibid*.

41 *Ibid*., 110. For a detailed discussed of Buffon's attack on Linnaeus see Philip Sloan, "The Buffon-Linnaeus Controversy," *Isis* 67, No 3. (1976) and the discussion of Sloan's ideas in Bowler, *Evolution, the History of an Idea*, 73-4.

42 Sloan, "Buffon, German Biology, and the Historical Interpretation of Biological Species," 109.

43 David R. Keller and Frank B. Golley, *The Philosophy of Ecology: From Science to Synthesis* (Athens: University of Georgia, 2000), 15-6.

when he ascribed greater nobility to the savage living in harmony with nature over civilized humans, and in the career of Johann von Goethe, when he young learners to both study *and* embrace the wilderness. More often, however, Keller and Golley focused on ecological thinking located within the work of writers who revolted against the "radically anthropocentric and thoroughly mechanistic world of modernity."[44] In addition to Rousseau and Goethe, they cited a number of influential authors that provided meaningful protest against the modernizing world: William Wordsworth; Ralph Waldo Emerson; Henry David Thoreau; Walt Whitman; and John Muir. All presented an Arcadian alternative to the urban, industrial society surrounding them.[45]

Keller and Golley claimed that "an ecological outlook does not mandate embracing the lessons of scientific ecology; nor do scientific ecologists necessarily have ecological world view."[46] But the ability to separate the two types of understanding should not automatically suggest, as seems to happen with these authors, that they rarely cohabit in the same individual. The aesthetic appreciation of wilderness associated with romantic writers and social activists was not evident in the professional work of Drude and his colleagues. Even so, the suggestion that a genuine split occurred between two kinds of thinking, or two kinds of thinker, constitutes an artificial intellectual bifurcation. Many life scientists were acutely romantic and almost all the early ecologists refer to their love of nature in childhood inspiring their studies in adulthood.[47] Furthermore, even in

---

44 Keller and Golley, *The Philosophy of Ecology*, 4. Colin Riordan also provides Goethe as an example of a scientist who rejected the scientific method. Goethe attacked the writings of Isaac Newton for reducing nature to an object for dissection. Riordan emphasized Goethe's passionate defense of nature as an instance of early green thinking. Goethe envisioned a seamless web encompassing human life as well as the natural environment, and his cause was taken up by the Romantics. See Riordan, *Green Thought in German Culture*, 6.

45 *Ibid*. The Arcadian protest was discussed by Donald Worster in *Nature's Economy: A History of Ecological Ideas* (Cambridge, UK: Cambridge University Press, 1985), see Chapter 1, esp. p 19. Keller and Golley follow the themes of romantic ecology forward into the twentieth century, looking at Robinson Jeffers (1938); Edward Abbey (1988), Gary Snyder (1974), Barry Lopez (1990), and Terry Tempest William (1995). The authors note that Aldo Leopold (1886-1948) and Rachel Carson (1907-1964) were both scientists, but decide that the two are better remembered for their social commentary. The distinction they make in this case between what individuals are trained in and what they are "remembered for" is problematic – Leopold and Carson's respective careers in science informed their commentary, and it is evident that in the previous century numerous scientists had expressed concern about human mismanagement of natural resources.

46 Keller and Golley, *The Philosophy of Ecology*, 3.

47 *Ibid*., 3-4. The authors argued that all ecological thinking until Darwin constitutes proto-ecology, and that the majority of ecological thinking in nonscientific literature is reacting against the older mechanistic model of nature. Scientific ecology, in their view, is merely a continuation of that model. They claimed that the "coupling of literary ecology to scientific ecology has caused chagrin for many scientists who have struggled to distinguish ecology as a legitimate scientific pursuit." They identified non-scientific ecology with the humanities, and reported that one ecologist "laments" that "theological parallels will continue to be applied to scientific ecology until specialists in the field shake off the mystical associations of romanticized ecology." The assumption that any association with the non-scientific community (academic or otherwise) would automatically lessen legitimacy is questionable.

the nineteenth century "scientific ecology" had distinguished itself a different kind of science. Keller and Golley recognized this distinction when they discussed ecology's emphasis on direct observation. They claimed that the recognition of patterns in nature does not necessarily require instruments or machines because nature, as they asserted, could be directly experienced. The idea of "experiencing" nature suggests the use of qualitative statements, an approach that was often anathema to the so-called hard sciences.

Keller and Golley claimed that there were connections between nonscientific and scientific forms of ecology, and they set out to clarify those distinctions by tracing genealogies of romantic ecology, political ecology, and scientific ecology. Classifying, labeling and describing ecological thinkers appears to be a particularly appropriate approach, since life science studies nature in almost the exact same way. The problem then becomes the same one faced by generations of taxonomists: what to do with individuals that seem to defy classification or to deserve multiple labels? The simplest option is to identify some dominant characteristic and lump otherwise dissimilar individuals together. Yet this approach is an imperfect solution. In Keller and Golley's monograph, they offered the American diplomat George Perkins Marsh as an example of a conservationist. They pointed out that he was once called "The Father of American Ecology," but implied that his interest in conservation somehow separated him from the development of the scientific field. The evidence, on the contrary, indicates that Marsh was both a high-profile ecological thinker and a conservationist. Marsh was multilingual and a polymath, well-versed in a number of scientific subjects. The network approach can avoid this pitfall: Marsh can be seen as an interesting figure in the history of ecology not because he was an example of a type of thinker, but rather because he was a link between several different communities of knowledge. Marsh, however, was a latecomer to this kind of synthetic work. An earlier, better example is Alexander von Humboldt, who Drude considered to be a leader in the second phase of ecology.

The Second Phase: Humboldtian Science

Humboldt, a Berliner of aristocratic heritage, has been referred to as a "dashing disciple" of Goethe.[48] Humboldt studied physics and chemistry at the University of Göttingen where he befriended Georg Adam Forster, translator of explorer Louis-Antoine de Bougainville's well-known travelogue, *Voyage Round the World* (1777),[49] and then trained at the Freiburg Mining Academy and emerged as a prize student of well-known geologist Abraham Gottlob Werner of

48 Robert J. Richards, *The Tragic Sense of Life: Ernst Haeckel and the Struggle over Evolutionary Thought* (Chicago: University of Chicago, 2008), 1. He notes that Alexander von Humboldt, "a dashing disciple of Goethe," spends five years exploring the jungles and social character of South and Central America, and that his travels inspire Charles Darwin to join the Beagle.

49 Frank N. Egerton, *Roots of Ecology: Antiquity to Haeckel* (Berkeley: University of California, 2012), 121.

the Freiberg School of Mines.[50] The Wernerian approach was a water-based conceptualization (sometimes referred to as "Neptunian") that accentuated the mineral's external characteristics and keyed "formations" into ordered strata and their fossils.[51] Through Werner's connections, Humboldt's first post-graduate placement was as an Inspector of Mines, but he demonstrated more interest in the mosses and fungi he found in mines than in a profession as an inspector.[52]

Today, Humboldt is considered a Romantic, a cult of personality, a founder of modern geography, and an early key contributor to ecology. He created "a science that focused on material interactions but interpreted them as parts of a coordinated whole in which each natural phenomenon was interlinked with all the others."[53] Humboldt was not only interested in how organisms connected, but also how people connected. The Humboldtian tradition, or Humboldtian science, is at its core an expansive network of people and their writings. Riordan saw Humboldt as one of the first intellectuals involved in conservationism: in 1799, he coined and promoted the term *Naturdenkmal* (natural monument) to denote a natural feature worth preserving.[54] Bowler and Morus maintained that it was under "the influence of Humboldtian science" that naturalists began to engage in ecological thinking once they examined how the distribution of animals and plants was determined by their environment, including the soils, rocks, climate and other aspects of a given region.[55] Based on Humboldt's publications and correspondence, historian Aaron Sachs has gone even further and argued that Humboldt was the first ecologist.[56] Sachs supported his argument by emphasizing that Humboldt was interested in connections. Almost half a century after his trip to South America Humboldt explained in his masterpiece, *Cosmos*, that by "considering the study of physical phenomena…we find its novelest [sic] and most important result to be a knowledge of *the chain of connection*, by which all natural forces are linked together, and made mutually

50 Suzanne Zeller, "The Colonial World as Geological Metaphor: Strata(Gems) of Empire in Victorian Canada," *Osiris* 15, *Nature and Empire: Science and the Colonial Enterprise* (2000), 88-91. Werner's student, Robert Jameson (1774-1854) became the University of Edinburgh's professor of natural history in 1804. Jameson created an unofficial corps of overseas observers from voyaging British military and administrative personnel. All Jameson students tended to seek similarities between what they observed and European formations.

51 *Ibid*.

52 Jean-Marc Drouin, "Botanical Geography," in *The European Origins of Scientific Ecology (1800-1901)*, ed. Pascal Acot, *Editions Des Archives Contemporaines* (Amsterdam: Gordon and Breach, 1998), 11.

53 Bowler and Morus, *Making Modern Science*, 221. For a thorough discussion of Humboldt's conception of nature, see Andrea Wulf, *The Invention of Nature: Alexander von Humboldt's New World*. Vintage Books, New York: 2016.

54 Riordan, *Green Thought in German Culture*, 8.

55 Bowler and Morus, 221.

56 Aaron Sachs, *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism* (London: Penguin Books, 2007), 2. Wulf also considers Humboldt the father of an environmental movement, see *The Invention of Nature*, p 66.

dependent on each other."[57] When Sachs studied Humboldt, he was struck by Humboldt's "deep feeling of awe and appreciation for the great variety of landscapes and culture" and suggested that "by tracing common patterns throughout the colonial world, Humboldt's universal sciences actually revealed the social and ecological damage wrought by colonialism."[58] He found that, far from being a mystical romantic, Humboldt presented "a complicated, dirty, difficult unity," yet it was one that many readers nevertheless found inspirational.[59] One of those inspired readers was Charles Darwin, who sent data and manuscripts to the older scientist, and at one point claimed that he owed his entire career to constant re-reading of Humboldt's *Personal Narrative*.[60]

None of these contemporary historians, however, were first to claim Humboldt for ecology. In 1904, Oscar Drude argued that the second period of ecology was led by Humboldt, whom he claimed was the first creative genius in the field and "undoubtedly guided by the ecological spirit."[61] Humboldt called upon botanists to take up the study of plant geography, which he conceived as the examination of plants "on the basis of their local association in various climates."[62] He grouped plants by climate, differentiating between where they were "scattered" or isolated, versus where they dominated. Drude acknowledged that Humboldt's system had defects which he identified as arising from confusing vegetative form with systematic character, but he also noted that the French-Swiss botanist Augustin Pyramus de Candolle soon remedied these defects and in the process of doing so, lay the foundation for the study of flora from the evolutionary view.[63] The two colleagues took plant biology dramatically forward in a few short years. Systematic study of such relationships within nature became the main impetus of Humboldt's lifelong "project," as Bowler and Morus discussed in detail, but he also suffered from wanderlust that he found himself suddenly

57 *Ibid*., 12, quoting Humboldt, *Cosmos*, "Introduction," I:I. Emphasis added.

58 *Ibid*., 13.

59 *Ibid*.

60 *Ibid*., 14. See Sachs' footnote 18 on p 380: Darwin asserted that his "whole course of life is due to having read and re-read Humboldt's work," and, in a note to Humboldt himself, he thanked his mentor for contacting him. The first instance is as reported in Worster, *Nature's Economy*, 132. The excerpt is from Darwin's letter of November 1, 1839, American Philosophical Society, Humboldt microfilm collection, F #870, reel 2).

61 Drude, "The Position of Ecology," 180.

62 *Ibid*., 180. See also Patrick Blandin, "Ecology: From a Crossroads Discipline Towards a Synthetic Science," in *The European Origins of Scientific Ecology (1800-1901)*, ed. Pascal Acot, *Editions Des Archives Contemporaines* (Amsterdam: Gordon and Breach, 1998), 2-19.

63 Drude, "The Position of Ecology," 181. A.P. de Candolle concentrated on the physical factors that influenced the distribution of different plant species, focusing on the limitations that specific climates and soils created. The absence of limiting factors therefore permitted dominance.

able to assuage when he came into a considerable inheritance from his mother.[64] In 1798, on a trip to Paris to acquire scientific instruments, he met Admiral Louis Antoine Bougainville and was recruited to join the French explorer's next expedition.[65] That journey was postponed due to the ongoing political upheaval in France, and Humboldt decided to travel to Spain with Bougainville's botanist, Aime Bonpland, and seek permission from King Carlos IV to explore in New Spain instead. The Spanish monarch granted him extensive concessions to explore, collect specimens, and make geographical and astronomical observations. Humboldt was just returning from a five-year long journey through Venezuela, the northern Andes, Mexico, and Cuba, when on a whim he decided to stop in Philadelphia and meet the writer of the Declaration of Independence. American Thomas Jefferson benefit from the detailed ecological information Humboldt had amassed before his sponsor in Spain.

Historian Laura Dassow Walls explained how Humboldt's methodology came to influence American governmental expeditions. The visit developed into an ongoing correspondence with Jefferson and his political colleagues, Albert Gallatin and James Madison. Members of the nascent network requested and granted favors as needed to assist the work intellectuals marginalized during the turmoil of the Napoleonic wars, and from these initial connections a cross-Atlantic scientific network grew.[66] In 1815, Humboldt arranged for two young Americans, George Ticknor and Edward Everett, to study at Gottingen under German naturalist Johann Blumenbach. During his stay, Ticknor became close friends with Humboldt.[67] Later on, Humboldt sent European scholars to teach in New England, including Swiss biologist Louis Agassiz. Humboldt's influence was also felt through his publications. For example, the American essayist and poet Ralph Waldo Emerson became enamored with Humboldt's travel diaries and in turn introduced them to his colleague Henry David Thoreau. Walls demonstrated dozens of interconnections confirming Humboldt's place in the history of ecology.[68]

Humboldt's career reveals close links between botany, geology, geography, and politics at the beginning of the nineteenth century. It also emphasized the potent influence of personal

64 Humboldt's relationship with his mother was close but often strained. He was deeply depressed after she succumbed to cancer, but nevertheless "felt her influence like a clamp to be resented and loosened." He continued to suffer from apparitions from her ghost (meant literally), but his annual income suddenly increased to six times that of his superior, the Superintendent of Mines. Financial independence allowed both he and his brother to pursue long-held interests in science and politics. See Helmut DeTerra, *Humboldt: The Life and Times of Alexander Von Humboldt, 1769-1859* (New York: A.A. Knopf, 1955), 67-8.

65 Egerton, *Roots of Ecology*, 121.

66 Laura Dassow Walls, *The Passage to* Cosmos*: Alexander Von Humboldt and the Shaping of America* (Chicago: The University of Chicago Press, 2009), 103-106.

67 *Ibid*., 116.

68 *Ibid*., 120.

connections at the time. Like other well-known students of Abraham Werner, Humboldt made important contributions to geology through memoirs, maps, and public appearances. Humboldt spent most of the fifty-five years after his journey to the Americas analyzing "those precious specimens" he had collected on his expedition.[69] In the process, he developed a radical approach to nature and humanity that makes him relevant to present-day ecology. The goal for his trip to the Americas had been to "recognize the general connections that link organic beings" and to "study the great harmonies of Nature."[70] He established the technique of botanical arithmetic to quantify species richness relative to genera, a technique elaborated by others to study levels of endemism, and suggested comparative study of New and Old World biota in order to better understand the larger philosophical question concerning the origin of species.[71] He inspired giants of the Victorian era, including Charles Darwin. Aspiring scientists read his books, attended his lectures, and sought his attention. Humboldt remained the nineteenth century's most influential scientist until 1859, the year he died and Darwin published *The Origin of Species*.

Whether or not Humboldt is considered the "first" ecologist, increased credit must be allotted to his role in the early ecology network. This claim can be made if for no other reason than the German savant's incredibly high profile. In September 1869, German biologist Ernst Haeckel's new term *oekologie* was still not widely known, but an entire front page of the *New York Times* was dedicated to Humboldt, for a double anniversary honoring the centennial of his birth and the decade since his death. It is both curious and telling that across the United States, speeches, banners and statues were presented in honor of this Prussian-born, French-speaking explorer of South America. In Boston, Agassiz, gave a two-hour speech regarding the significance of his old mentor within the world of science, and particularly in America.[72] Agassiz explained that Humboldt's cosmic theories connected all the world's "mutually dependent features, including human beings in all their diversity and strife, in one ecological web."[73]

---

69 *Ibid*., 2.

70 As quoted in Sachs, *The Humboldt Current*, 2. From letters dated March 11, 1799, in Madrid to the King of Spain while obtaining permission to explore the Spanish colonies. Translated from the French by Sachs. The letters are located at the *Archivo Historico Nacional* in Madrid, *Seccion Estado, legajo* 4709. Credit is provided to Miguel Angel Puig-Semper for discovering the documents. They have since been reprinted in his article, "Humboldt, un Pruisano en la Corte del Rey Carlos IV" *Revista de Indias* 59 (Mayo-August 1999), quotes on pp. 337 and 354.

71 James T. Costa, "The Darwinian Revelation: Tracing the Origin and Evolution of an Idea," *BioScience* 59, no. 10 (2009): 887.

72 Sachs, *The Humboldt Current*, 11.

73 *Ibid*., 12. See also his footnote on p. 379, where he notes that the speech has been published as *Address Delivered on the Centennial Anniversary of the Birth of Alexander von Humboldt; Under the Auspices of the Boston Society of Natural History; with an account of the evening reception* (Boston: Boston Society for Natural History, 1869).

Context for the Second Phase of Ecology

The appearance of ecology was also tied into the history of western North America. In 1803, Thomas Jefferson purchased the Louisiana territories from France's Napoleon Bonaparte for fifteen million USD. The Louisiana Purchase greatly enlarged the territory of the USA and created new borders with the British in the north and the Spanish in the south.[74] Memorialization of this pivotal event in world history provided the rationalization for the exposition that Drude and his colleagues spoke at a century later. In the history of science, however, the Purchase is remembered as a prelude to scientific exploration.

At the time of the Purchase, the location of the borders was left vague and estimates regarding the resident population were unreliable.[75] Jefferson wished to better understand the new acquisition, and the Corps of Discovery was specifically North American scientific exploration. Any pretense of an isolated American brand of science, however, was illusory. Ties to the European natural history network were still evident, from the training of the explorers, to the analysis of the specimens collected, to the flow of people, materials, and ideas across the increasingly arbitrary borders of western North America.[76] These ties remained constant for the next hundred years.[77] The American westward expansion occurred in tandem with an expansionist, exploratory phase of

74 The territory of Louisiana was defined as the entirety of the Mississippi watershed, which extended north and west to the Missouri Coteau. Today, the northernmost portion lies within Canadian territory. The 49th parallel was eventually established as the northern border between the British and American territories, rather than the drainage basin. Two people standing on either side of the border, one in Saskatchewan and the other in Montana, would find that the plains continue unabated in all directions. As late as the 20th century, novelist Wallace Stegner remembers locals treating the border as "indistinguishable and ignored" as it "split a country that was topographically and climatically one." See Western Literature Association*, A Literary History of the American West* (Fort Worth: Texas Christian University Press, 1987), 1011.

75 French estimates of the border and the populations provided during the negotiations were rough: the line would run south from the Lake of the Woods to New Orleans, and the west from the Mississippi to the Rocky Mountains. The population was thought to be somewhere between 60,000 and 100,000, less than half of which were white. The residents were not thought to govern themselves, either before or after the Purchase. See Alexander DeConde, *This Affair of Louisiana* (New York: Scribner, 1976), 209-11.

76 The 49th parallel was an abstract notion made real by political inclination. States and provinces in the Atlantic and Pacific coastal regions generally reflect some environmental or cultural reality. In the centre of the North American map, these realities devolve into crudely defined political regions based on latitude and longitude lines drawn with a straight edge. The borders of the Canadian province of Saskatchewan, and the American states of Wyoming and Colorado, create minimalistic rectangles that do not reflect a single physical entity.

77 John Darwin has demonstrated that immigrant flow became a form of social renewal in settlement colonies. Printed literature from Britain was circulated and imperial associations collated the experience and expertise of businessmen, doctors, surveyors, engineers, foresters, agronomists, teachers, and journalists. Return flows of experience, scientific information and academic talent also influenced British culture. See John Darwin, *The Empire Project*, 4-5.

British colonization.[78] Historian James Ronda identified three motives that sparked Anglo-American exploration of the western territories: the construction of empire; the pursuit of private profit; and the conduct of scientific inquiry.[79] The motives were rarely independent of one another. Political and intellectual borders of the British world system were permeable and accepted influence from America, Europe, and Russia.[80] The white population of the Mississippi drainage basin contained a mix of French, British, Spanish, and German residents that hosted an undetermined number of American hunters, trappers and merchants. At the beginning of the nineteenth century Americans dominated most of the populated areas by "infiltration, immigration, and trade" while refusing to shift allegiance to Spain or France.[81] Histories of North American scientific exploration have often been lumped together with volumes about the travels and adventures of these interlopers.[82]

After the Purchase, Jefferson initiated a plan he had long cherished. He sent an armed expeditionary party trained in collecting scientific information to expand basic knowledge of the Missouri River watershed and seek a water passage across America. Scientific journeys in the time of Jefferson were still the province of gifted amateurs, although the traveling companions were often led by military commanders.[83] The Corps of Discovery is conventionally discussed as the beginning of American development of western North America, but from another perspective it concluded a chapter in history. Historian John Logan Allen reminded his readers that "other men, at other times, had used different words to say the same thing and had called the water communication a Northwest Passage or a Passage to India."[84] The hope for a short water passage to Asia had been

78 Suzanne Zeller discussed this exploratory phase from the perspective of the British. See Zeller, *Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation* (Toronto: University of Toronto, 1987). John Darwin conceived the same period as part of the rise of Britain, an upward trajectory that continued to the mid-19th century when the British empire was the central territorial component of a "world-system" that dominated constitutional, diplomatic, political, commercial, and cultural relationships. See Darwin, *The Empire Project*. James Ronda provided the details of the political situation as it applied to the North American West, when the region became a battleground and prize in an epic clash involving Russians, Spaniards, Americans, Canadians, and Native peoples. See Ronda, "American Exploration in the Age of Jefferson," in *A Continent Comprehended*, ed. John Logan Allen, North American Exploration (Lincoln: University of Nebraska, 1997), 9.

79 *Ibid*.

80 Darwin, *The Empire Project*, 7-8.

81 DeConde, *This Affair of Louisiana*, 245.

82 Ronda has discussed how exploratory and travel literature dovetailed. See Ronda, "American Exploration in the Age of Jefferson," 9-12.

83 *Ibid.*, 13 and 20. Bowler and Morus also discussed the expeditions that were launched into remote regions to satisfy curiosity about the world and reiterated that in the earliest phase of life science, there were strong links between imperialism and science. Bowler and Morus, *Making Modern Science*, 218.

84 John Logan Allen, *Passage through the Garden: Lewis and Clark and the Image of the American Northwest* (Urbana: University of Illinois, 1974), xix.

the initial impetus for all western exploration based from Europe, and the American Corps of Discovery would, in fact, be the last major attempt to locate it. The choices and possibilities for the water passage had diminished over time, as Allen has recounted. Great Britain had already unsuccessfully attempted to locate a water passage via the Arctic and North-Western waterways of present-day Canada. A final hope was placed in establishing a route that led up the Missouri River into the foothills, across a short portage, and then down a major river artery that led to the Pacific.

Sachs argued that Jefferson nurtured America's western obsession more than any other political leader.[85] While not a traveler, Jefferson had been collecting books on the geography of the North America since the 1780s. The region was thought to exist in a pristine state.[86] Aside from establishing a trade route, Jefferson envisioned a future American society of agrarian smallholders based in the West.[87] Lewis and Clark would do little to dispel the notion of the West being a pristine garden ready for settlement, although they did finally disprove the possibility of a Northwest Passage through North America.[88] They would provide new details on the geography of the upper Missouri and a description of the Great Plains with its "vast, open expanses of treeless grasslands and their teeming herds of deer, elk, antelope and bison…"[89] They also accumulated scientific specimens that later became vital to biodiversity measurements.[90]

Lewis and Clark set out in the spring of 1804. The British government, basing their speculation on reconnaissance missions through the Saskatchewan River system and the northern

---

85 Sachs, *The Humboldt Current*, 3. DeConde similarly finds that Jefferson and his government were fixated on acquiring and exploiting the western territories, see DeConde, 249-50. See also Jon Kukla, *A Wilderness So Immense: The Louisiana Purchase and the Destiny of America* (New York: A.A. Knopf, 2003); Peter J. Kastor, *The Nation's Crucible: The Louisiana Purchase and the Creation of America* (New Haven: Yale University, 2004).

86 The West was not a "pristine" environment, in fact the region was wracked with major changes at the time. Not only was the climate unusually cool, the economic and ecological system in place for centuries was disintegrating. The global fur trade had introduced commercial hunting to the Plains, which was devastating the populations of fur-bearing mammals. In particular, the bison, a keystone species of the region, was facing pressure from what appears to be a combination of climate fluctuations, over-hunting, and increased competition for grazing material. The horse had rapidly multiplied since its re-introduction via Spanish invaders, and cattle herding was also becoming common practice. For further discussion, see Alywnne Beaudoin, "What They Saw: The Climatic and Environmental Context for Euro-Canadian Settlement in Alberta," *Prairie Forum* 24, no. 1 (1999); Douglas Bamforth, "An Empirical Perspective on the Little Ice Age Climatic Change on the Great Plains," *Plains Anthropologist* 35 (1990).

87 Sachs, *The Humboldt Current*, 3.

88 Allen, *Passage through the Garden*, 395. For example, they carried with them explorer Alexander Mackenzie's book.

89 *Ibid*.

90 Biodiversity studies are generally thought of as a scientific topic, but they are also fundamentally historical in nature. This is because biodiversity researchers are looking at the change in species population and distributions over time. "Species richness" is a key measurement that indicates the number of species found in a given area.

Rockies, suspected the Missouri region would prove unsuitable for European-style agriculture.[91] In reality, neither the Europeans nor the Americans knew much about the Missouri territory in terms of geography or geology.[92] Jefferson also did not possess any scientific intelligence about the southern plains of the Louisiana territories, which until recently had been administered by the Spanish. It had already been determined that the southern region would be explored in a separate expedition at a later date. Then, only a few days after Lewis and Clark and their party left, "there appeared at the president's dinner table a man fresh from the borderlands [with New Spain], a scientific traveler who had spent the past year digging in Mexican mines and archives."[93] That man was Humboldt.

Sachs opened his monograph on Humboldtian science with a prologue entitled "Humboldt in America, 1804-2004." The first date refers to May 6, 1804, when Humboldt chose to make a detour while returning to his home in France from a trip conducting scientific exploration in South America. He had decided to see Philadelphia and fulfill a yearning to meet Jefferson, who currently led the country then considered the best hope for democratic republicanism.[94] Humboldt soon had good reason to question his decision. That very night, he and the crew members nearly lost their lives, as well as all his specimens, in a terrible sea storm. [95] Humboldt did arrive safely on May 24, and stayed on in the United States for six weeks, hosted by Jefferson and other members of the American Philosophical Society. Historian Helmut de Terra prefaced his biography of Humboldt with a description of the savant arriving in Philadelphia, along with remarks on how he endeared himself to Americans and their president, and on occasion referred to himself as "half-American" for the rest of his life.[96] The president and the scientist would discover they shared a wandering spirit and numerous scientific interests.[97] Sachs has described the visit in detail, noting that Humboldt and Jefferson compared examples of mammoth's teeth, discussed Aboriginal languages, and debated the exploration of the American continent.[98] Jefferson "pumped his guest for information about the territory surrounding the Mississippi River" and Humboldt "was ecstatic to oblige."[99] The two

91 *Ibid*., 14-18.

92 *Ibid*., 2-3.

93 Sachs, *The Humboldt Current*, 4.

94 *Ibid*., 3.

95 *Ibid*. Sachs quotes a compilation of Humboldt's multi-volume personal diary. See *Reise auf dem Rio Magdalena, durch die Andean und Mexico*, Vol. I, ed. Margot Faak (Berlin: Akademie Verlag 1986), as indicated in Sach's footnote on p 397. Quote is translated from the French by Aaron Sachs.

96 DeTerra, *Humboldt*, vii.

97 Sachs, *The Humboldt Current*, 3.

98 *Ibid*., 4.

99 *Ibid*., 4 and 6.

distinguished colleagues would continue to correspond regularly until Jefferson died in 1826.

Humboldt missed meeting Lewis and Clark by a few days, but Sachs argues that "virtually every other American expedition of the nineteenth century would bear the mark of his influence" if for no other reason than because surveyor Zebulon Pike copied Humboldt's main map while it lay open on Secretary Albert Gallatin's desk in Washington. Although Humboldt had indeed lent his map of Mexico, the *Carte Générale du Royaume de la Nouvelle-Espagne*, to be copied for Jefferson's library, Pike made his copy surreptitiously and then utilized it a few years later without attribution when he published his map of "The Internal Part of Louisiana" (1810).[100]

Late in 1804, Humboldt returned to France and was soon introduced to the other participant in the Louisiana Purchase, Napoleon Bonaparte. It was their first and also their last face-to-face contact.[101] Humboldt was attracting the attention of the entire Western world and was mobbed every time he appeared in public. After the one such presentation at the *Jardin de Plantes*, Napoleon invited Humboldt to the gardens at Tuileries for a celebration of his own imminent ascension to the imperial throne. When they were introduced, the politician asked the scientist (rhetorically) if he collected plants. When Humboldt smiled in response, Bonaparte sneered that his wife did that as well, and walked away.[102] Napoleon had already indirectly affected early ecology when his military entanglements forced Humboldt to re-route his exploratory journey, and again when he sold the Louisiana territory to Jefferson and enabled another exploration program. The main aim of the sale was to eliminate any threat that the Americans might join with the British against him. Napoleon used the $15 million he received from the purchase of Louisiana to fund his armies and initiate a decade of French domination in continental Europe. As a consequence, the English reneged on a promise to relinquish Malta to the French because they wished to use the island in defence should Napoleon attack Egypt or India.

When the truce between England and France broke down and Britain declared war, early ecology was once again indirectly influenced by Bonaparte's political machinations. Anti-English

---

100 *Ibid*., 6. See also the corresponding footnote on p. 377. A letter from Humboldt to Gallatin on June 20, 1804 provided a reminder that he needed his map returned before his imminent departure; a letter from Humboldt to Jefferson, December 20, 1811, notes Pike's plagiarism. Sachs relies on de Terra's compilation of Humboldt's correspondence, see 792-802.

101 Humboldt and Bonaparte were exact contemporaries (both born in 1769) and successful in their fields, but they seemed destined to be adversaries. In 1797, Napoleon's campaign in Italy spoiled Humboldt's plan to climb volcanoes there. In 1793, France invaded Egypt and forced Humboldt to cancel another expedition. Humboldt then made his application to explore for Spain. By the time of his return to France in 1804 he had repeatedly expressed concern that Napoleon's megalomania interfered in France's intellectual progress. See Sachs, 37.

102 Sachs recounts this often-discussed incident, see 38. The same description is available in DeTerra, *Humboldt*, see 198. Sachs cites esp. Douglas Botting, *Humboldt and the Cosmos* (London: Michael Joseph, 1973), 177-201. Sachs also notes another quotation from Botting, where Humboldt commented that the emperor seemed "full of hatred toward me." See Botting, 179 and Sachs' footnote, 386-7.

sentiment in France led a disaffected young scientist named James Smithson to re-write his will, leaving an endowment that would change the power dynamics of science in nineteenth-century America. English residents in France expected they would be expelled at some point once the two countries were at war, but they were surprised when Napoleon ordered the immediate arrest of all English males in France between the ages of 18 and 60.[103] Smithson, an amateur chemist and the illegitimate son of an English duke, found himself in the unfortunate position of being born in Paris but naturalized in England and therefore subject to the decree. Smithson happened to be on an excursion to the Low Countries when the edict came down. Unable to return to his living quarters, he removed himself to Germany,[104] settling for a time in Hesse while he waited for the political situation to calm.[105] His family connections were tenuous, he was a confirmed bachelor, and his true family was the circle of savants that he traveled with, so he stubbornly resisted having the upheaval on the continent change his residence or halt his personal research program. Yet by 1805 he found himself on the run attempting to avoid an especially determined French undercover policeman, known as Mengaud, who suspected that the fashionable young chemist was actually a spy.[106] Smithson was subsequently harassed, his scientific research was confiscated, and once Prussia declared war on France (in 1806) he was forced to seek a route to England via the North Sea. By the time he made it to Hamburg, the city was overrun with French soldiers, and Smithson was promptly arrested.[107]

Throughout this difficult period, Smithson maintained faith in the international brotherhood of science, and he developed a hatred of, and disrespect for, political machinations that interfered with the pursuit of knowledge. Even when Smithson was released in 1809, he did not immediately set out to England but took a final tour of German cities, relying on a forged passport and his excellent command of French to keep him safe while cementing his precious network of scientific contacts.[108] Therefore Smithson was in Berlin during what historian Heather Ewing has argued was a key moment in its cultural and intellectual history, when the parlors of the city were filled with intellectuals susceptible to the stirrings of idealism, romanticism, and German nationalism.[109] During this excursion he met Humboldt. After Napoleon's army invaded and conquered Prussia,

---

103 Heather P. Ewing, *The Lost World of James Smithson: Science, Revolution, and the Birth of the Smithsonian* (New York: Bloomsbury, 2007), 220.

104 *Ibid*., 221.

105 *Ibid*., 226.

106 *Ibid*., 227.

107 *Ibid*., 247.

108 *Ibid*., 252-3.

109 *Ibid*., 253.

Humboldt was similarly treated as a spy, and although he continued to base himself in Paris, Napoleon's officers would open his mail and regularly ransack his apartment.[110] It is therefore unsurprising that Humboldt, like Smithson, would have an ambivalent relationship with his adopted home. While visiting Berlin in 1809, Humboldt was promoting a radical idea to gather all the learned societies and institutions of the capital into a new university where research would be included as part of its essential work.[111] The *Lehranstaldt* would restore Prussia's reputation after the military campaign suffered under Napoleon. Ewing suggests that this exposure contributed to Smithson's later decision to leave his considerable wealth to the American government in order to establish a rival scientific institution on the western side of the Atlantic—the Smithsonian. [112]

Smithson's generosity towards America occurred despite his tacit integration into the highest circles of London's scientific community. During the Napoleonic period he was heavily involved with the Royal Society Council and the Royal Institution, and he was friendly with leading gentlemen scientists from James Hutton to Sir Humphry Davy. But London never became home. When Napoleon's regime finally fell in 1814, Smithson returned to Paris, although he continued to visit London on occasion. When he died in 1829 his will left living means to his servants and the proceeds from his property (without the ability to sell those properties) to his nephew. By that point Smithson had been away so long that his passing was barely noted in London.[113] The will contained a caveat that if the nephew died without heirs, the entire estate should go the federal government of the United States in order to establish an institution for the increase and diffusion of knowledge in Washington, DC. When that exact situation came to pass six years later, the bequest was received with bafflement by the American government but was enacted, albeit with considerable administrative headache. The Smithsonian Institution was finally created in 1846 by an Act of Congress, and almost from the beginning it functioned as a major repository for scientific collections.[114] The dramatic growth of life sciences in the nineteenth century would not have been possible without the establishment of major specimen repositories on both sides of the Atlantic. The Smithsonian was one of the first, large public institution in North America. Its appearance was followed by a rapid explosion in new "cathedrals of science," as historian Susan Sheets-Pyenson

110 Sachs, *The Humboldt Current*, 37.

111 Ewing, *The Lost World of James Smithson*, 254.

112 *Ibid*., 253.

113 *Ibid*., 304-16. Given the state of the finances of Smithson's nephew when the young man died six years later, the decision not to simply hand over the fortune was probably prescient. The young man had squandered all the liquid assets he had inherited.

114 Debra Lindsay, *Science in the Subarctic: Trappers, Traders, and the Smithsonian Institution* (Washington, DC: Smithsonian Institution, 1993), 13. By the middle of the nineteenth century, it was at the forefront of the collecting mania that swept across the English-speaking world.

has referred to natural history museums. By 1900, there were 250 museums in the United States, the same number in Britain, 300 in France, and 150 in Germany.[115] Their operation created a community of "classifiers, compilers and collectors" out of which the field of ecology was born.[116]

The new director of the Smithsonian, American engineer Joseph Henry, chose Spencer Fullerton Baird, a gifted young naturalist, to be his curator. Henry's decision was made largely because of the younger man's excellent reputation but also in order to obtain access to his considerable specimen collection, which Baird duly donated to the museum after he became Assistant Director in 1850.[117] Although Baird attended a local college in his youth, he was basically self-taught. He did receive some tutoring from his brother, who was an avid birdwatcher, and he benefited from the mentorship of naturalist John James Audubon, who taught him how to draw scientific illustrations.[118] When Baird joined the staff "many North American plants and animals were still unknown to scientists; only the most preliminary steps in the identification, classification, and cataloging of North American flora had been completed; and questions regarding geographical distribution, climate variation, and the relationships among the plants, animals, climate, and topography of an ecosystem were in the formative stages."[119] Under his care, the ornithological collections at the Smithsonian Institution grew from six thousand specimens to over two million. Aside from cataloging, Baird researched geographical distribution, and he also established and edited *The Review of North American Birds*.[120]

The Smithsonian became a vital part of the early ecology network, providing space for natural history collections and employment for graduates of life science programs. The institution also became heavily involved in public outreach through museums, educational programming, and events like universal expositions. The Smithsonian was instrumental to the success of many of the displays at the Louisiana Purchase Exposition. Not only did the staff provide the stunning ornithological aviary, they also contributed specimens to indoor zoological exhibits, for example providing a skeleton of a blue whale, and they were key to assembling the outdoor ethnological exhibits. The Smithsonian also provided permanent storage for many of the records and specimens

115 Susan Sheets-Pyenson, *Cathedrals of Science : The Development of Colonial Natural History Museums During the Late Nineteenth Century* (Kingston, Ontario: McGill-Queen's University Press, 1988), 9.

116 *Ibid*., 3.

117 *Ibid*., 15.

118 Like Smithson, Audubon was French born, but he grew up in the Caribbean and was sent to the United States by his father in 1803 so that the young man could avoid conscription into the Napoleonic wars. He is known for *The Birds of North America*, first published in 1827, and his contributions were memorialized in 1905 through naming of the Audubon Society, an American conservation organization.

119 Lindsay, *Science in the Subarctic*, 14.

120 *Ibid*.

amassed whenever the United States hosted universal exhibitions, beginning with the Philadelphia World's Fair in 1877.

The exact centenary between Humboldt's visit to Jefferson and Drude's speech in St. Louis is of course a coincidence, but the repeated appearance of these dates and names indicates that there exists a real, specific, and special time line for the development of ecological thought between 1804 and 1904. Early ecology may also be understood as a series of landmark publications, as Oscar Drude suggested, and these publications will span approximately the same period of time. Looking at early ecology as a social network, however, offers a more thorough understanding of the interests of ecological thinkers, and in addition can offer insight on how knowledge communities emerge and thrive. Early ecologists created opportunities to meet with each other and further scientific inquiry, whether the individual's initial interest was derived from intellectual or economic motivation, and whether their primary employment was as a researcher, teacher, or outside academia. The resulting community was shaped by forces of attraction and repulsion, and the primary research questions under investigation necessarily came to reflect the changing needs of both the participants and the society they moved within. In short, early ecology did not so much "grow" or "mature" so much as it adapted to its own environment.

CHAPTER FOUR

1859: THE *ORIGIN* AND ECOLOGY

The speakers in the ecology section at the International Congress of Arts and Science (ICAS) were deeply influenced by Charles Darwin and his research into "the species question." The species question was essentially a mixture of difficult but related questions that tended to arise when identifying species and their relationship to other organisms. Its relevancy to ecological thinking was obvious: as the study of the relationship between organisms and their environment, ecology and the species question are inextricably linked by subject matter and by the careers of individual investigators. Darwin's career was not outlined by any of the ICAS presenters—it is possible they presumed the story to be common knowledge. At the turn of the twentieth century, the general public was aware of Darwin and the vigorous debates that continued in scientific circles about evolution and speciation.

During an exploratory voyage to South America (1831-1836), Darwin became interested in how the nature of species and varieties was filled with uncertainty.[1] He carefully observed finches on the Galapagos Islands, which he considered to be "very curious." [2] Historian James Costa claimed that "Darwin seemed to glimpse the significance of these birds, but he did not yet realize that the finches of those equatorial islands were even more remarkable, nor that the tortoises told a similar story."[3] After his return, Darwin published a travel journal while quietly furthering his own investigations. Darwin conferred with ornithologist John Gould in March 1837, learning that more than two-thirds of his Galapagos birds were new species, unique to the islands but unmistakably South American in affinity. Historians agree that Gould's analysis was most likely the final factor convincing Darwin of transmutation.[4] In 1838, Darwin hit upon the mechanism of natural selection. It is debated by historians of science whether he vacillated in his concept of speciation aftwards. Biologist Ernst Mayr contends that Darwin considered and rejected a variety of additional theories in the 1840s, but stayed constant once he had worked out the major features of natural selection.[5] Historian James Costa, on the other hand, has argued that the process was more

---

1 James Costa, "The Darwinian Revelation: Tracing the Origin and Evolution of an Idea." *BioScience* 59, no. 10 (2009), 887.

2 *Ibid*. As summarized by Costa, based on Frederick Burkhardt, *Correspondence of Charles Darwin* Vol 1 (Cambridge, United Kingdom: Cambridge University Press, 1991), 484.

3 Costa, "The Darwinian Revelation." Costa's remarks here are based on Frank J. Sulloway, *The Beagle Collections of Darwin's Finches (Geospizinae)* (London: British Museum of Natural History, 1982).

4 *Ibid*.

5 Ernst Mayr, The Growth of Biological Thought. 408-10. Cambridge: Harvard University Press, 1982.

gradual.[6] In either case, he chose not to publish his theory. Historian Sander Gliboff described how Darwin became "notoriously reticent" about publicizing his theory of evolution.[7] Years after his voyage to the South Pacific, and only after being compelled to do so by his mentor, Charles Lyell, Charles Darwin finally offered his thesis on speciation in *On the Origin of Species by Means of Natural Selection: Or, the Preservation of Favoured Races in the Struggle for Life*.

Darwin's examination of the species question during the interval between his voyage on the *Beagle* and his publication of the *Origin* is pivotal to understanding the progress of mid-century biology but has been thoroughly discussed elsewhere. Costa summarized the historiography and concluded that the notion of evolution by natural selection is too easily perceived by the readers of today as a monolithic idea grasped more or less at once by Darwin.[8] He attributed this assumption in part to Darwin's presentation of his theory as a logical whole in 1859. Darwin conceived of the mechanism by the late 1830s, drafted a concise version by 1842, a longer one by 1852, but the *Origin* was not released until 1859. He used the extra time to approach individual scientists with his ideas, test the waters, and develop a network of future supporters.[9] Costa emphasized that understanding the full picture of Darwin's creative process was possible only once his correspondence, notebooks, and other private writings became available for study. From his own examination of these sources, Costa argued that the central mechanism of species diversification, the principle of divergence, was not evident until well into the 1850s. For this discussion of ecological thinking, it is Darwin's connections with the other scientists working in research institutions that is most relevant, in particular those of his friends and acquaintances attached to botanical gardens, herbariums, and museums. One of these supporters was Joseph Dalton Hooker, who became part of a small group of Darwin's confidantes that was examined by historian Iain McCalmon and dubbed Darwin's "Armada," due to the fact that they all vociferously defended natural selection on Darwin's behalf and they all participated in sea voyages.[10]

Darwin's colleagues and correspondents featured prominently in volatile debates about the nature of species, the naming of species, and the relationship between species that occurred in the mid-nineteenth century. At the ICAS, German botanist Karl Goebel reminded his audience of the powerful influence Darwin and his disciples wielded when they "turned more attention again to

6 Costa, " The Darwinian Revelation," 886-7.

7 Sander Gliboff, *H.G. Bronn, Ernst Haeckel, and the Origins of German Darwinism: A Study in Translation and Transformation* (Cambridge, Mass.: MIT Press, 2008), 1.

8 Costa, "The Darwinian Revelation," 886.

9 Gliboff, *Origins of German Darwinism*, 1.

10 Iain McCalman, *Darwin's Armada: Four Voyages and the Battle for the Theory of Evolution* (New York: W.W. Norton & Co., 2009), 13.

the function of single plant organs" because "all form-relations arise through adaptation."[11] Such inquiries were mainly conducted with the resources of botanical gardens. Historians Peter Bowler and Iwan Morus explained how the purpose of botanical gardens was to identify commercially useful plant species but many of the personnel were also deeply interested in new scientific theory.[12] Kew Gardens was the center of both kinds of effort in Britain. Its scientific direction had been previously established by naturalist and factotum Sir Joseph Banks, although the research center truly flourished under the direction of the Hookers. Under the Hookers' directorship, plants had to be sent to Kew for identification because colonial workers were not considered competent enough to identify their own plants.[13] Darwin's friend was therefore not only a custodian of plants, he wielded a considerable amount of power within the scientific community. Hooker's counterparts across the Atlantic were Smithsonian curator Spencer Fullerton Baird and botanist Asa Gray, who held the Fisher Professorship in Natural History at Harvard.[14] The three men became involved in the mid-century controversy over the origin of species via a crisis in biology over nomenclature.

The Nomenclature Crisis

The nomenclature crisis is as much a story about ego and power as it is a scientific debate. Throughout the nineteenth century, conflict arose concerning the right of individuals and institutions to re-name botanical specimens and issue authoritative publications of their schematics. The location of the naming was nearly as important as the person doing the work. The rise of the American natural history repositories therefore factored into the crisis as it escalated. By the 1850s the Smithsonian was competing with equivalent institutions in Europe. Baird focused on expanding the collections and had the complete support of Director Joseph Henry. His work, however, was not proceeding without outside opposition. Henry and Baird faced resistance from the universities of New England. Harvard University provided both a friendly rival, professor of botany and herbarium Asa Gray, and a scheming antagonist, professor of comparative anatomy and director of the museum of comparative zoology, Louis Agassiz. Gray and Baird were both consummate professionals, seeking to position their institutions as great clearinghouses of botanical data.[15]

---

11 Karl F. Goebel, "The Fundamental Problems of Present-Day Plant Morphology" *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908), 95.

12 Peter Bowler and Iwan Rhys Morus, *Making Modern Science: A Historical Survey* (Chicago: University of Chicago, 2005), 218.

13 Kingsland, Sharon E. *The Evolution of American Ecology, 1890-2000* (Baltimore: Johns Hopkins University Press, 2005), 18-21. Kingsland discussed how botany was the "big science" of the mid-19th century. During this period, museums and herbaria were research centers, acting as hubs of worldwide colonial enterprises.

14 Elizabeth Keeney, *The Botanizers: Amateur Scientists in Nineteenth-Century America* (Chapel Hill: University of North Carolina, 1992), 34.

15 *Ibid*., 23.

Agassiz, on the other hand, was intensely critical of Baird as a taxonomist and dismissive of Gray on a more personal level.

Agassiz, a Swiss biologist who boasted French and German training and recommendations, came from a different background than Gray and Baird. Gray and Baird had connections, but were essentially self-made men. In continental Europe, however, natural philosophers from Humboldt's generation could lend their own prestige to younger life scientists even late into the 1830s. Agassiz was one such beneficiary. He had relocated from Switzerland to Paris as a young man and attempted to make his way on extremely limited means, spending what he had to study fossils and employ a scientific artist, Joseph Dinkel from Munich. Then he spent several months in 1832 under the mentorship of German naturalist Alexander von Humboldt. Humboldt did not instruct him in science so much as in manners and scientific society: he provided "the form and attitude he thought essential for a young man who wanted to succeed in the world."[16] Agassiz went on to create a public image of himself as the successor to French anatomist Georges Cuvier, arguing that the modern naturalist was simply the trained and truthful interpreter of God's universe. With the assistance of his family and, on occasion, Humboldt's intercessions, Agassiz managed to secure non-monetary offers to research in Berlin and Paris and then was able to parlay these into a small salaried position in Neuchâtel, Switzerland. He initially intended to leverage this teaching position into a permanent position at a German university.[17] Instead, he spent over a decade in the town of six thousand, transforming it into a beehive of his own scientific activity. In the process, he made an international reputation for himself publishing some pioneering papers on the effects of glaciation, but any gains were made at the loss of many friendships. A consistent pattern of overextending his resources, both material and human, eventually eroded his position in Switzerland and by the late 1840s, Agassiz was forced to relocate and start fresh in America. At Harvard, his increasingly outdated philosophical position would lead to conflict with Baird and Gray.[18]

In Britain and North America, economic botany reigned supreme, and this limitation meant that the focus remained on amassing collections.[19] In the Anglo scientific world, advances in geology were garnering most of the government's attention and funding.[20] This preference was in part because geology correlated well with the progressive outlook and the utilitarian expectations

16 Edward Lurie, *Louis Agassiz: A Life in Science* (Chicago: University of Chicago, 1960), 66.

17 *Ibid*., 69-71.

18 *Ibid*., 83-85.

19 A. Hunter Dupree, *Asa Gray, 1810-1888* (Cambridge, United Kingdom: Belknap Press, 1959), 98.

20 Robert M. Thorson, *Walden's Shore: Henry David Thoreau and Nineteenth-Century Science* (Cambridge, Harvard University Press, 2015), 300.

of science by society in the English-speaking world.[21] Louis Agassiz and Charles Darwin both embarked on their careers during the 1830s, but they came to different conclusions regarding the relationship between organisms. Their lines of inquiry reflected the mentorship they received and the research programs they developed. What Humboldt was to Agassiz, geologist Charles Lyell became for Darwin. Lyell's *Principles of Geology* was first published in three volumes between 1830 and 1833. He provided a strict version of uniformitarianism which emphasized that causes of geological change observed acting today were wholly adequate to explain past changes and that the same causes always behaved at the currently observed rates.[22] The "steady-state world" concept permitted scientists to observe geological and biological formations in the present in order to understand the past. Biogeographer David Wilkinson identified some ecological thinking evident in Lyell's work. It was obvious to Lyell that competition occurred between humans and many other species: humans were causing some species to become extinct, and habitat destruction and introduced species were implicated alongside direct hunting.[23] Mayr discussed this point more extensively explaining that although Lyell saw species as constant types, he noted that new types might be introduced when others went extinct and attributed this phenomenon as an effort to fill vacancies.[24] Lyell also wrote on the effect of vegetation on climate and suggested that vegetation increases continental precipitation.[25] Mentorship between Lyell and Darwin began with the young Darwin reading Lyell's work during his trip to the South Pacific and Lyell's ideas seem to have been a contributing factor in the line of research he eventually undertook. The link between Lyell and natural selection is not absolute, however: Lyell was also a major influence on Canadian geologist John William Dawson, who remained a devoted adherent to day-age creationism and an implacable enemy of Darwinian evolution throughout his career.

In 1838, the same year Darwin hit upon the idea of natural selection, Asa Gray visited Europe for a year, although his biographer emphasized that the American botanist was "no mere

---

21 Sally Gregory Kohlstedt, *The Formation of the American Scientific Community : The American Association for the Advancement of Science, 1848-60* (Urbana: University of Illinois, 1976), 17.

22 David M. Wilkinson, "Ecology before Ecology: Biogeography and Ecology in Lyell's 'Principles'," *Journal of Biogeography* 29, no. 9 (2002), 1109. Wilkinson cites Stephen Jay Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time* (Cambridge, Mass.: Harvard University Press, 1987).

23 Wilkinson lamented that this observation contained no hint of regret: he quotes Lyell as saying "if we wield the sword of extermination as we advance, we have no reason to repine at the havoc committed." *Ibid*., 1113.

24 Mayr, *Growth of Biological Thought*, 406-8.

25 *Ibid*. Wilkinson cites Richard A. Betts, "Self-Beneficial Effects of Vegetation on Climate in an Ocean-Atmosphere General Circulation Model," *Geophysical Research Letters* 26, no. 10 (1999). These views were widespread at that time, with many writers arguing that the long-term clearance of vegetation in Europe and the more recent clearances in North America had led to climatic change. See, as Wilkinson suggests, J. R. Fleming, "Charles Lyell and Climatic Change: Speculation and Certainty," *Geological Society Special Publication* 143 (1998).

graduate student seeking crumbs of knowledge from the greats."[26] In England, Director of Kew Gardens William Hooker greeted him as a colleague and hosted his stay in London. Of particular interest to Gray were the Western North American collections that had been amassed by British naturalist Thomas Nuttall. Nuttall was one of the foremost plant collectors in North America at the time, but he lacked the academic credentials and social clout to obtain a permanent position as an instructor at a college. He had received some income maintaining the garden that had been established by naturalist William Dandridge Peck at Harvard, but when he resigned in 1833 in order to go on a collecting journey to the Pacific an unschooled gardener was hired to replace him. While Gray worked over Nuttall's collections at Kew, he became friendly with Hooker's son, Joseph, who was twenty-one years old at the time and at home studying in preparation for a stint as a surgeon on an exploring mission.[27] Gray and the younger Hooker made the rounds of scientific London together, even meeting naturalists Richard Owen and Charles Darwin together on one occasion.[28]

After completing his study of Kew's North American holdings, Gray visited Paris. Historian A. Hunter Dupree claimed that Gray studied the North American plants in the French herbaria more closely than the French themselves, naming one new plant in the process. By the time Gray reached Vienna, Gray was fully integrated into the European science network. His notes recognized the challenges of each place—for example, he expressed shock at the routine censorship of scientific publications in Austria, and found himself surprised to feel grateful for the relative "indifference" of Americans to scientific work.[29] In Germany, he became friends with the de Candolles, another father-son duo in botany, and was exposed to Asian plants for the first time, which would prepare him for later contributions on discontinuous species.[30]

Gray returned home the first American-born botanist "so familiar" with European herbaria that he could perform "authoritative work" in taxonomy.[31] In 1840, Gray visited Nuttall, then living in Philadelphia, hoping to discuss the collections he had studied, but instead created a lifelong enemy. Gray felt slighted that his advice went either ignored or uncredited in Nuttall's subsequent publications, and Nuttall took to referring to Gray as a botanist that worked in the "closet" with

26 Dupree, *Asa Gray,* 74.

27 Dupree, *Asa Gray,* 74-75.

28 *Ibid*., 81. Meeting Owen and Darwin together was especially memorable since they became notable rivals later on.

29 *Ibid*., 86-9. The discussion of Austria is on page 89.

30 *Ibid*., 89.

31 *Ibid*., 92.

no field experience.[32] In 1842 Gray was awarded the position at Harvard that Nuttall had always desired but never obtained, one that combined a permanent professorship with supervision of Nuttall's old garden. Gray immediately set about exploiting his new friendships with European botanists to establish a trading network of plants.[33] Around the same time Nuttall made a trip to England to collect an inheritance and decided not to return to America.

As Gray was settling in at Harvard, Darwin was first drafting his thoughts on the species question. He surveyed the current theories on organic history, considering and then rejecting the notion of catastrophism and successive mass extinctions advocated by Louis Agassiz. In Germany, biologist Heinrich Georg Bronn was essentially following the same intellectual path as Darwin. Both reasoned that the causes of organic change were ultimately to be sought in the changing external environment, believed that maladapted forms could not readily perpetuate themselves, and began to consult each other's work.[34] Bronn emphasized that each species lived until gradual geological and environmental changes made its survival impossible—in this passage, he was deliberately taking issue with Agassiz and his notions of catastrophic mass extinctions and subsequent mass creations.[35] Neither Darwin nor Bronn took on Agassiz directly, however. Darwin in particular was essentially a recluse, and this tendency to hide away with his theory was intensified when Robert Chambers' popular history of evolution, *Vestiges of the Natural History of Creation*, was released anonymously in 1844, and then was soundly rejected by the scientific establishment, most notably in a review by Adam Sedgwick.[36] Gray also provided a scathing review where he denounced

32 *Ibid*., 98-9.

33 *Ibid*., 116.

34 Gliboff, *Origins of German Darwinism*, 10. Darwin was cited in Bronn's multi-volume *Handbuch einer Geschichte der Natur*. The book shows a number of similarities with Darwin's work in the *Origin*. Bronn also provided an overview of biogeography, analyzed the methods and accomplishments of plant and animal breeders, compared domestic with natural variation, undermined conventional assumptions about the fixity of taxonomic types, expounded upon the universality of Malthusian overproduction, and even describes existence in nature as a struggle. Gliboff draws attention to the fact that in Darwin's library, the *Geschichte* is one of the most heavily annotated works but is not suggesting any intellectual dishonesty, because there are important differences between Darwin and Bronn, as well. Bronn saw variation as the product of nature's laws, not as raw material to be further sorted and shaped: it was a successional theory, not an evolutionary one. See pp 3-12.

35 *Ibid*., 13. Also see page 25, where Gliboff endorses Lynn Nyhart's related discussion of how German biology succumbed to an intellectual and institutional splintering beginning in the 1840s, when research specialties and university chairs in zoology begin to multiply. The other side of this splintering was the fact that new specialties arose from diverse alliances. Nyhart has also argued that a biological perspective in Germany originated in a heterogeneous milieu, including museums, schools, zoos, and public enterprises. See Lynn Nyhart, *Modern Nature: The Rise of the Biological Perspective in Germany* (Chicago: University of Chicago Press, 2009), 1-4.

36 For a discussion of the social and scientific reception of the *Vestiges*, see James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation* (Chicago: University of Chicago, 2000).

Vestiges as constituting as much an attack on science as it was an attack on religion—especially its claim that all its theories were new.[37] Gray's professional profile was raised in the process, and he set about trying to use the public interest to make his department at Harvard a center of the latest scientific activity. On the other side of the Atlantic, Darwin was deeply disturbed by the voracious attacks on Chambers' book. While he had his own concerns about the content, particularly that Chambers had not addressed the coadaptation of life forms to one other, no was a mechanism for evolution suggested. He still did publish his thoughts, however, and instead convinced himself that he had to gather more evidence before making his thesis public. The delay was perhaps for the best: the book seems to have benefited from the extended gestation.[38]

In the early 1840s, Louis Agassiz had lost more than professional endorsement from the likes of Darwin and Bronn. He had quite deliberately scooped his friend Jean de Charpentier on glaciation theory, and had alienated a number of colleagues, including the future pioneer in plant morphology Karl Schimper, by jealously guarding or stealing priority credit. He had also married Cécile Braun, sister of botanist Alexander Braun, a well-mannered young German woman that could function as his artist, and he unceremoniously cut off his ever-faithful scientific illustrator Dinkel. His bride soon discovered that he expected her to illustrate for him, raise his children, run a household on a diminutive budget, and host a number of colleagues for extended visits. When the long-anticipated offer of a prime professorship in Germany finally came, Agassiz turned down the position at his alma mater in Heidelburg, simultaneously estranging his extended family and annoying his old mentor Humboldt. Essentially, he had grown accustomed to being a big fish in a little pond at Neuchâtel, but at this point he overstepped himself. Overburdened, Cécile moved out with their two youngest children in 1845. Agassiz, who was now heavily in debt and without sufficient emotional or financial resources to carry on as he had been doing, was saved once again by Humboldt, who produced a grant from Frederick William IV of Prussia for him to go to America and study the natural history of the New World. By the time Agassiz left in 1846 he had already arranged to lengthen the voyage from a single season to a two-year stay, and do some publishing and lecturing in Massachusetts. His biographer claimed that when Agassiz crossed the Atlantic "America knew it was welcoming a man deeply dedicated to a self-appointed mission to uncover nature's innermost secrets."[39] In short, the man was proving to be one of the great divas of science.

Agassiz was initially hosted by Asa Gray and soon became impressed with the quality of scholars, if not the state of educational institutions and science in Boston.[40] Agassiz set himself up

37 Dupree, *Asa Gray,* 146-8.

38 Costa, "The Darwinian Revolution," 890.

39 Lurie, *Louis Agassiz*, 121.

40 Dupree, *Asa Gray,* 150-3; see also Lurie, *Louis Agassiz, 123-7.*

as a social butterfly with a public address, and another private, secret office to work at, mimicking Humboldt's work arrangements. He began to study the natural history of America in earnest, again sometimes accompanied by Gray.[41] His stay was financially successful and within six months, he had paid off his European debts. He had by then expended his German grant but was living comfortably from the proceeds of American lectures. His Boston supporters were determined not to lose Agassiz, and Agassiz privately had no intentions of leaving his pleasant new home.[42] The amiable relationship between Agassiz and Gray soured, however, particularly after a sizable donation to Harvard that Gray might have benefited from was diverted to funding Agassiz.[43]

By the autumn of 1847, Agassiz had secured a three-year appointment at Harvard and he debuted his new authority by attending the meeting of the American Association of Geologists and Naturalists (which that year was transformed into the American Association for the Advancement of Science) and presenting no less than twenty-seven papers.[44] By this time, Gray's patience with Agassiz's antics had evaporated. Agassiz had some fanciful ideas. For example, he favored the notion that forests in North America were more diverse than those in Europe and probably resembled the forests that covered Europe in the Miocene time.[45] More importantly, Gray rightly assessed that the ongoing demands from Agassiz threatened the resources available for his own department. Gray was able to offset this loss in part by marrying the daughter of a prominent Boston lawyer. Jane Loring Gray became a constant presence at the botanical garden, and they had a long and happy marriage, without children.[46] Their combined wealth would later be left to Harvard. Gray also became an unofficial advisor to the Smithsonian, due his friendship with Joseph Henry. Gray's position in botany was assured by his position as director of the herbarium and as a publisher of textbooks. His major contribution to early ecology, however, would be made via a vigorous defense of Darwin, which was first conceived as a set-down against Agassiz.

Agassiz's exit from Europe had proven well-timed, as his previous position in Switzerland soon fell along with the rest of the tiny academy in Neuchâtel during the revolutions of 1848. He sent for his assistants and his library, and set about recreating his "scientific factory" in Boston. He did not make any effort to send for Cécile, who in return expressed no interest in migrating to America as she was ill and heavily reliant on the support of their families. He next organized a natural history exploration of the Great Lakes that would especially focus on the effects of

41 *Ibid*.

42 *Ibid*., 132.

43 Dupree, *Asa Gray,* 154.

44 Lurie, *Louis Agassiz*, 132.

45 Kingsland, *The Evolution of American Ecology*, 10.

46 Dupree, *Asa Gray*, 181-4.

glaciation. Upon his return, he received word that his wife had died of tuberculosis and that his assistant had been gossiping about his domestic woes to Boston society; moreover, the same assistant then attempted to blackmail him under the threat of publicly slandering the new Professor. When Agassiz proved uncooperative, the entirety of his personal and professional woes came under the scrutiny of Boston society. He successfully defended himself and received two awards: a five-year extension to his appointment, and the affection of a local débutante. By 1850, he had settled in at Harvard, professionally and personally. He married Elizabeth Cabot Cary, and brought over his eldest son Alexander.[47]

The same year, Asa and Jane Gray took an extended trip to Europe. They attended the Crystal Palace exposition, witnessed zoologist Thomas Henry Huxley present his papers based on the results of his work on the *HMS Rattlesnake*, and visited with Joseph Dalton Hooker, who was fresh returned from India with a new collection. Gray spent months working at Kew, this time focusing on the Wilkes Expedition plants. Gray also had lunch with Hooker and his friend Darwin on one occasion, the latter who he again found to be "a lively, agreeable person."[48] These connections provided Gray with a ringside seat to Darwin's Armada as it developed. They would also deliver him the means to challenge Agassiz in a public forum in 1859.

While the Grays were in Europe, issues at home began to arise about nomenclature used in scientific volumes.[49] In 1842, the rules of the British Association regarding nomenclature had gone into effect. Previously, species were normally given two names, the first identifying the genus and the second the species within that genus. These were not fixed in perpetuity, but might be revised. A species might move to a different genus, a single species might be split into two or three species, or two species might be lumped together. When revisions occurred, the taxonomist might append his name. The problem was how to decide when revisions were legitimate. The British Association rules were aimed at zoology, and granted highest authority to the first person to define a new genus or describe a new species. At Kew Gardens, priority was not necessarily the very first specific name but rather to the name given to a plant when it was placed in what was considered to be its "true genus," even if the botanist making the revision did not retain the original specific name. Asa Gray, unsurprisingly, showed allegiance to the Hookers and chose to embrace the Kew Rule.[50] Gray and his close associate, American botanist John Torrey, also maintained they had the discretion to translate Latin names into English for their botanical volumes.[51]

---

47 Lurie, *Louis Agassiz*, 155.

48 Dupree, *Asa Gray*, 190-2.

49 *Ibid*., 193.

50 Kingsland, *Evolution of American Ecology*, 43.

51 Dupree, *Asa Gray*, 193.

The dispute over nomenclature also came to involve Agassiz and Baird. Agassiz was disputing the validity of many of the morphological characters Spencer Fullerton Baird had chosen to define species, as well as the consistency and accuracy of Baird's nomenclature.[52] Their differences escalated into a vicious argument about reptile classification that reflected fundamental differences in approach.[53] Baird was able to increase the species known to science and reorganize the classificatory system as he saw fit, based on his own expansive collections.[54] His reorganizations were not always definitive, but they did reflect the conceptual change that was evident among taxonomists at the time.[55] Debra Lindsay wrote that while Baird was focused on taxonomic relationships, Agassiz could not embrace "the environmentalist viewpoint" as Baird did, nor would he change established names.[56] Agassiz's devout religious beliefs impeded his objectivity about evolution, his public reputation was based on giving lectures on the relationship between God and nature, and his intellectual pedigree rested on mentorship and endorsement he received from essentialists Cuvier and Humboldt. For the rest of his lifetime, anti-evolutionists had the option to "cloak themselves" in the respectability Agassiz had created for himself as the most famous zoologist working in America.[57] This very reputation, however, became a target for Gray's outrage, and Gray's connections with the Darwin circle would enable his vindication by the end of the decade.

In Figure 4.1 (see next page), a detail of Gray's social circle is provided. Attention is drawn to Gray's friendship with Charles Darwin and Joseph Dalton Hooker. Interconnections based on mentorship, friendship, familial relationship, and working relationships are shown in the diagram. The idea of antipathy is also visualized, the prime example being between Gray and Agassiz. Complete names, birth and death dates for the individuals are provided in the appendices. A complete social network diagram for the early ecology network as discussed in this study is located in Appendix B.

52 See Debra Lindsay, *Science in the Subarctic: Trappers, Traders, and the Smithsonian Institution* (Washington, DC: Smithsonian Institution, 1993), 16.

53 *Ibid*., 17.

54 *Ibid*., 18.

55 *Ibid*.

56 *Ibid*.

57 Ronald Numbers, *The Creationists* (New York: A.A. Knopf, 1992), 7.

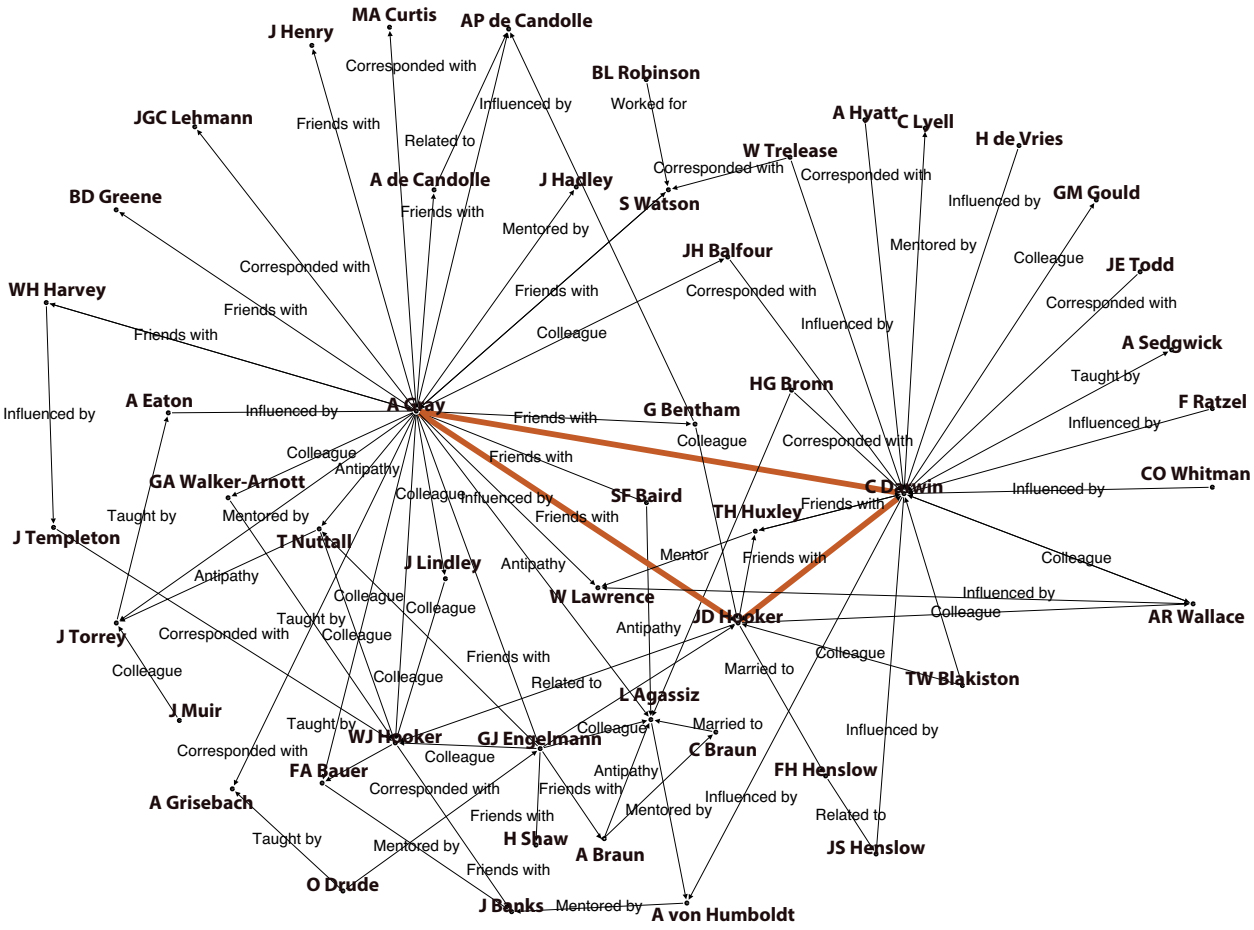

Figure 4.1. Asa Gray's connection with Charles Darwin and Joseph Dalton Hooker. The relationship is shown within their wider social circle. For complete names, see the appendices.

The Species Question

During the 1850s, Darwin continued to develop his data set as he inched towards publication. Much of this process occurred over extensive conversations with Huxley and Hooker, who were both amenable to letting their mild Anglicanism slide into agnosticism, all the while embracing the new idea of natural selection. Hooker wrote to Asa Gray that he was concerned about becoming, as historian Iain McCalman puts it, "tainted with Darwin's heresy."[58] Yet he nevertheless provided Darwin with all the might of Kew's collections and his own correspondence network.

By 1855, Gray was also corresponding directly with Charles Darwin. Gray's stature was

58 McCalman, *Darwin's Armada*, 576.3

considerable by that point, having spun together his influence in America's amateur collecting circles and his new connections with European biologists into a web that historian Elizabeth Keeney considered to be the most important botanical exchange in the nineteenth century.[59] Gray knew that Darwin was nearly ready to publish on speciation, but both thought he still had the luxury of time to make final adjustments. Darwin would be disabused of this notion after several of his friends, including geologist Charles Lyell, read Alfred Russel Wallace's paper on the Sarawak Law, which argued that every species that has come into existence has been coincident in both space and time with an allied species.[60] Lyell realized that Darwin was very near to losing priority for natural selection to the gifted young Welshman, and pressured his friend to speak out.

By 1859, life science was ready for the theory of natural selection. Darwin's studies of barnacles had bolstered his reputation as a serious scientist. His counterpart in Germany, Bronn, received a prize in 1857 from the French Academy of Sciences for his successional account.[61] There was also the favourable response to Wallace's paper on the Sarawak Law. JD Hooker possessed the record of plant specimens that would confirm natural selection for botanists, and also offered up his extensive connections with amateur collectors that would be receptive to the ideas. In just one example, in 1859 at Kew Hooker befriended a young soldier, Thomas Wright Blakiston, who was appointed as magnetical observer for an expedition planned through the Canadian prairies. The Palliser group was to explore the region as had Lewis and Clark in the Missouri basin, and hoped to prove Smithsonian physicist Lorin Blodget correct. Blodget had used climatic observations and forecasts to argue there may be favorable conditions in British territory for agriculture development.[62] Blakiston did not meet Darwin during his stay but he was deeply influenced by his brush with the Darwin circle and would later write on discontinuous species that he studied in northern Japan.[63] There were many amateur collectors like Blakiston working in the outreaches of the British empire at the time who were receptive to Darwin's ideas.

---

59 Elizabeth Keeney, *The Botanizers: Amateur Scientists in Nineteenth-Century America* (Chapel Hill: University of North Carolina, 1992), 34.

60 Alred Russel Wallace, "On the Law which has Regulated the Introduction of New Species." *Annals and Magazine of Natural History 2nd Series* 16 (1855), 184-196.

61 Gliboff, *Origins of German Darwinism,* 3. It was released in print the next year as *Untersuchungen uber die Entwickelungs-Gesetze der organischen Welt*. The title translates as *Investigations into the Developmental Laws of the Organic World*.

62 Suzanne Zeller, "The Colonial World as Geological Metaphor: Strata(Gems) of Empire in Victorian Canada." *Osiris* 15 (2000), 101.

63 Irene M. Spry, *The Palliser Expedition: The Dramatic Story of Western Canadian Exploration, 1857-1860*, Western Canadian Classics (Saskatoon: Fifth House Publishers, 1995), 84-90. The paper he eventually published was "Zoological Indications of Ancient Connection of the Japan Islands with the Continent," *Miscellanea Ornithologica* 32 (Tokyo: Asiatic Society of Japan, 1883).

Darwin's circle also had some indication of where resistance would be found. There were the religiously inclined, which Huxley would take on in the form of a high profile debate against Bishop Samuel Wilberforce.[64] Gray similarly confronted the undiscriminating religiosity of his old opponent, Louis Agassiz. All too recently Agassiz had published the first volume of his *Contributions to the Natural History of the United States*, which included an "Essay on Classification" that explained nature as the result of a divine plan and then set out to promote it based on his own prestige, that of his old master, Cuvier, and all the force of idealist philosophy.[65] He appeared at an American Association for the Advancement of Science (AAAS) meeting held in Montreal that year to promote his publications.[66] By the late 1850s, the AAAS had lost most its former vigor and was functioning poorly.[67] The Montreal meeting in 1857, which was hosted by Canadian geologists John William Dawson and William Edmund Logan, ended up notable not for any discussion on the species question, but rather as the meeting when the Logan first presented his famous Laurentian analysis.[68] Agassiz, Logan, and Dawson all became high-profile detractors to natural selection in the scientific world.[69] Gray, on the other hand, despite remaining a devout Presbyterian, had already became associated with members of the Armada when Darwin wrote to him in July earlier that year:

---

64 William Irvine, *Apes, Angels, and Victorians: The Story of Darwin, Huxley, and Evolution* (New York: McGraw-Hill, 1955), 4-6.

65 A. Hunter Dupree, "The First Darwinian Debate in America: Gray Versus Agassiz," *Daedalus: Proceedings of the American Academy of Arts and Sciences* 88, no. 3 (1959), 561. See Louis Agassiz, *Contributions to the Natural History of the United States of America* (Boston: Little, Brown and Co., 1857).

66 Dupree, *Asa Gray*, 248. The AAAS meeting is also briefly discussed in Zeller, "The Colonial World," 98.

67 Kohlstedt, *The Formation of the American Scientific Community*, 224. The AAAS appeared to be broad based (tolerant of class and gender) and international in scope. In reality, it was urban, eastern, and leadership-focused. Of the 215 foreign members listed that year, 81% were Canadian. Females were permitted in the organization, but never made welcome. When Henry Rogers proposed to emulate a British Association for the Advancement of Science (BAAS) policy of admitting women at half price to encourage attendance, Lewis Stained replied that women already accompanied family members and that was "annoyance enough," see p. 206. Eunice Foote, a non-member, presented a paper at the AAAS meeting, but the clique of powerful leaders based in Washington and Cambridge, Mass. participated and published the most.

68 Zeller, "The Colonial World," 98. Logan and Dawson had been introduced years before by English geologist Charles Lyell. Dawson was mentored by Lyell, and Logan came into Lyell's orbit when he had taken on the Geological Survey of Canada in the 1840s. Logan envisioned his time with the Survey as a stepping stone to work in the British Isles, but his efforts were largely ignored. Dawson, for his part, took the position of principal at McGill in 1855 after the University of Edinburgh's Sir Roderick Impey Murchison rejected him for the college's natural history chair as a "mere colonist," and Dawson in turn appointed Logan as professor of geology and palaeontology.

69 Kohlstedt, *The Formation of the American Scientific Community*, 115. James Dwight Dana opposed the content of Lewis' book, *The Six Days of Creation* (1855), in the process emerging as a defender of science and geology but, like Joseph Henry, was a scientist and a Christian who preferred an option that reconciled his two identities.

> *All my notions about how species change are derived from long continued study of the works of (and converse with) agriculturists and horticulturists, and I believe I see my way pretty clearly on the means used by nature to change her species.*[70]

Three months later, Darwin sent Gray an outline of his ideas on the origin of species. This correspondence would end up providing one of the bases for his priority over Alfred Russel Wallace when the issue arose after the papers of Wallace and Darwin were presented at the Linnaean Society.

Gray took up the mantle of defending Darwin within the complex social network of North American science. The main obstacle would be, of course, Agassiz. Gray chose his battle carefully and focused on the aspects of the *Origin* related to discontinuous plant species. In 1858, Gray was provided with a collection of dried plants from Japan, which put him in the unique position of being able to compare Japanese flora with American flora, and hence to make a significant contribution to plant geography.[71] He completed his analysis of the collection on December 10 and one month later, held a meeting of the American Association for the Advancement of Science (AAAS) in the parlor of his father-in-law's home. Gray offered his opinions on discontinuous species to the twenty-two members present, which included Agassiz, and demonstrated how the samples in his possession probably arose from a single, local creation of species.[72] Agassiz responded that Gray's samples could not be the result of extensive migrations since they were in competition: the "warfare" evident between the species indicated that they never would have arisen from a single pair. Dupree claimed that with this statement Agassiz nearly declared the principle of natural selection himself, only to use his perception of a struggle between species in order to bolster his *denial* of a genetic connection between species.

The debate between Gray and Agassiz spilled over beyond this initial meeting to meetings and publications throughout the spring of 1859. Darwin's name was not invoked in the first exchanges regarding the origin of species between Gray and Agassiz, and no appeals to the usual passions regarding religion or race were permitted. Then, on April 25, Gray finally discussed the theories of Darwin and Wallace directly. On May 12, Gray entertained the Cambridge Scientific Club at his home explicitly in order to introduce Darwin's theory to North America. The exchanges between Gray and Agassiz are the direct equivalent of the confrontation between Thomas Henry

---

70 Costa, "The Darwinian Revelation," 888. Costa is quoting Darwin from Frederick Burkhardt, see *Correspondence of Charles Darwin* 6 (Cambridge, UK: Cambridge University Press, 1991), 431. Costa claims that Darwin found domestication "so compelling an analogy to the natural process of species change" that it should be understood as the initial inspiration for his ideas on both transmutation and natural selection. But, as Costa discusses in his article, the attempt to use a domestic example for a natural process of species change is problematic.

71 Dupree, "The First Darwinian Debate in America," 561.

72 *Ibid*., 562-5. See also Dupree, *Asa Gray*, 285-88.

Huxley and Bishop Samuel Wilberforce in London, though they are not as well known. The main deficiency on the American side was not the absence of a sensational press, but a comprehending audience: according to historian Dupree, so few made the connection between these technical debates on geographic distribution and the key to the origin of species that "the whole thing had to be repeated many times by lesser men in less civilized surroundings."[73]

In November of that year, *The Origin of Species* was released, and it was ignored by the AAAS.[74] In Germany Darwin was recognized by several experts in morphology. His theory fit well with what was current in German biology. Historian Sander Gliboff has reviewed and dismissed a large body of secondary literature that claims pre-Darwinian German morphologists preferred idealized archetypes, deterministic scales and laws of development, and limitations on variation and creativity.[75] Gliboff argued instead that Darwinian concepts of variation and historical contingency were neither unanticipated nor unwelcome.[76] During Darwin's "long delay," Heinrich Georg Bronn's publications had paralleled Darwin's research in some ways: he too sought alternatives to idealized archetypes, linear scales of development, and a static view of nature. The two naturalists were both pursuing a historical view of life. Both believed that clues to the nature and causes of historical change would emerge not only from palaeontology and comparative morphology, but also from studies of variation, geographic distribution, organism-environment interactions, and even artificial breeding.[77] Nevertheless, Darwin was surprised and gratified when Bronn, by then Germany's most prominent paleontologist, responded positively to his complimentary copy of the *Origin*. Despite his skepticism of species transformation he provided a positive review for his journal and inquired about a German translation.[78] Bronn ended up doing the translation himself, and the version was published the next year in 1860, immediately provoking new debates about morphology, systematics, palaeontology, and embryology.[79]

---

73 *Ibid*., "The First Darwinian Debate in America," 568.

74 Kohlstedt, *The Formation of the American Scientific Community*, 225.

75 Gliboff, *Origins of German Darwinism*, 5. Gliboff corrected the former depiction of pre-Darwinian German biology established by ES Russell and other pioneering historians of biology. The older examinations focused on morphology and the predominance of transcendental or idealistic interpretations of form. Gliboff argued that continuity between idealistic morphology and Darwinian thought was overstated. Other aspects have been grossly underestimated, for example the extent of Bronn's support for Darwin's work. A bias has been presumed to exist against variation and creativity in the pre-Darwin period, and to have carried over into the Darwinian period because pre-existing vocabulary was used in the translation. See Gliboff, 5-17.

76 Gliboff, *Origins of German Darwinism*, 6.

77 *Ibid*., 2-3.

78 *Ibid*., 1.

79 *Ibid*., 4.

The Long Shadow of Asa Gray

The debate on nomenclature in plants was sedate in comparison to the uproar concerning the diversity and geographical dispersal of human "varieties." Race was the single most polarizing topic in western science in the early 1860s, touching on every topic from religion to natural selection to the Civil War in the United States. Asa Gray was keenly aware of how the topics tended to bleed into one another and often expressed dismay at how the war had interfered with the work of his students. At the same, he became frustrated with the relative disinterest shown by his English friends regarding the ongoing American hostilities.[80] Throughout this period he continued to develop his extensive herbarium, library, and garden with his personal money, but after the Civil War concluded, Asa and Jane decided to donate it all to Harvard. Additional patrons were solicited to provide money for a new brick building, and Gray and his 200,000 herbarium specimens moved in, cementing his reputation as the undisputed leader of American botany, and America's foremost disciple of Darwin. This support did not mean, however, that Gray himself did not have questions for Darwin. The genius of Darwin's mechanism was its dispensing of the need for a supernatural force; but the main issue Americans like Gray faced in *accepting* natural selection was this very absence of a single creative force. In the *Origin*, Darwin's self-professed goal "to overthrow the dogma of separate creations" allowed for at least one creative act to get life going. This declaration prompted Gray to suggest that Darwin should allow for a separate creation for humans. Darwin rejected this advice.[81] In fact, by 1871 in *The Descent of Man*, Darwin used "uncompromisingly naturalistic language that contrasted sharply with the Biblical story of Adam and Eve."[82] Gray, however, continued to seek out a compromise that did not estrange him from his adherence to the Presbyterian faith.

Although the majority of professional naturalists in America had embraced the evolutionary origin of species within a decade of the publication of the *Origin*, most remained skeptical about the primacy of natural selection in the evolutionary process, and continued to investigate alternative explanations. They were particularly attracted to any theory allowing for the potential of inheriting environmentally induced characteristics.[83] Even "Darwinian" scientists like Gray accepted Darwin's authority, but clung to religiosity. They preferred to see creation as a supernaturally initiated process. In the early 1870s the Smithsonian's Joseph Henry wrote to Gray: "I have given the subject of evolution much thought, and have come to the conclusion that it is

80 Dupree, *Asa Gray*, 309-13.

81 Numbers, *The Creationists*, 4.

82 *Ibid*., 5.

83 Numbers, *The Creationists*, 5.

the best working hypothesis which you naturalists ever had."[84] Henry and Gray would continue to seek out a compromise (unsuccessfully) but shied away from overt creationism. At the other end of the spectrum, Agassiz publicly rejected Darwin but quietly began a long retreat from some of his older theories. Shortly after the publication of the *Origin* Agassiz turned over his notes reconciling the "vanished" species of Europe now found in America to his student, Nathaniel Shaler. Shaler rejected the idea that Europe became impoverished in species as a result of poor treatment of the environment: he instead saw the continents as being simply at different stages of history.[85] Agassiz then invited a former student, the religious zealot John McCrady, to teach at Harvard in 1873. The same year, Asa Gray retired and handed his Directorship over to his long-time friend, American botanist Sereno Watson. The two hand-offs could not have ended more differently. Agassiz died soon afterwards and McCrady took over the zoology position, only to be forced to resign in 1877 by the university administration, leaving John Dawson as one of the last prominent creationists in North American science.[86] In contrast, Gray spent the last years of his life retracing old journeys and friendships, and ensuring his legacy.

Just before retiring Gray gave an address in California. He reminded his audience that the hypothesis regarding disjunct distribution supposed:

> *a gradual modification of species in different directions under altering conditions, at least to the extent of producing varieties, subspecies and representative species, as they may be variously regarded; likewise the single and local origination of each type, which is now almost universally taken for granted.*[87]

The last part was optimistic. Even in the 1870s Darwin's thesis was not universal, and natural selection would lose ground in some circles for years to come. Gray's thoughts on disjunct distribution, however, continued to hold sway in American botanical circles. Gray had found that California and the east coast differed botanically in most ways, but the Atlantic United States,

---

84 *Ibid*., 11.

85 Kingsland, *The Evolution of American Ecology*, 10. He went on to promote the idea that the history of life progressed through stages marked by geologic epochs, and that Europe must have moved further ahead in its organic history than any other land. It was similar in spirit to Haeckel's notion of the stages of life being reproduced by the fetus with the human womb. Shaler thought that North America and Asia "lagged" by one geologic period; Africa and South America "lagged" behind even further; and Australia was farthest behind.

86 Numbers, *The Creationists*, 8-10. Dawson remained principal of McGill in Montreal, and managed to serve as president of both the American AAAS and the British AAAS. His influence as an administrator is obvious; as a religious scientist, it is less apparent. Avowed anti-evolutionists certainly appealed to his prestige, but it is not clear that his administrative positions allowed him to enforce his beliefs on many other scientists.

87 Gray, Asa. *Address of Professor Asa Gray: Ex-President of the Association*. Cambridge, Mass.: John Wilson and Son, 1873.

Japan, Manchuria and Northern China were astonishingly similar. In his speech, Gray used the sequoia tree to support his explanation. He demonstrated that relatives of sequoia were found on the Atlantic coast and in China, and yew trees that had the same distribution, and gave his final word on the subject of species distribution and race. It is distinctly ecological in tone:

> *It cannot be said now that these [sequoia] trees inhabit their present restricted areas simply because they are there placed in the climate and soil of all the world most congenial to them. There is much indeed that is congenial, or they would not survive. But when we see how Australian Eucalyptus trees thrive upon the Californian coast, and how these very redwoods flourish upon another continent; the so-called wild oat has taken full possession of California; how that cattle and horses introduced by the Spaniard have spread as widely and made themselves as much at home on the plains of La Plata as those of Tartary, and that the cardoon-thistle seeds, and others they brought with them, have multiplied there into numbers probably much exceeding those extant in their native land; indeed, when we contemplate our own race, and our own particular stock, taking such recent but dominant possession of this New World; when we consider how the indigenous flora of islands generally succumbs to the foreigners which come in the train of men, and that most weeds of all temperate climate are not "to the manor-born," but are self-invited intruders; - we much abandon the notion of any primordial and absolute adaptation of plants and animals to their habitants.*[88]

In 1877, Asa and Jane Gray made another trip to California, this time accompanying Joseph Dalton Hooker. The visit was again received by Californians with considerable excitement.[89] Throughout these final envoys, Gray steadfastly supported his old friend Darwin's theories.

Gray also left a legacy through mentorship, by tutoring bright students in botany and encouraging them to make the trek to Europe and build connections. The Chairman for the biology section at the ICAS, American botanist William Gilson Farlow, was one of these fortunate students. He had temporarily served as Gray's assistant around 1870, and he had also performed fieldwork at Woods Hole under the supervision of Smithsonian administrator Spencer Fullerton Baird. Farlow was interested in cryptogamic botany, a specialty not well-known in North America at the time, and therefore he was both obligated and delighted to pursue graduate studies with German botanist Anton De Bary at Strasbourg.[90] According to biographer Charles Loring Jackson,

---

88 *Ibid*.

89 Keeney, *The Botanizers*, 35. Keeney quotes a letter from a local collector to Gray sent after the expedition that explained photographs of he and Hooker were up for sale in the region. They were considered celebrities.

90 Charles Loring Jackson, "William Gilson Farlow (1844-1919)," *Proceedings of the American Academy of Arts and Sciences* 57, no. 18 (1922), 485-6.

Farlow's exposure to Gray and De Bary provided an ideal balance in his education, for Farlow came of age when "systematic botanists were spoken of scornfully as 'hay collectors,' and with the zeal of new converts most German botanists prided themselves on their ignorance of flowering plants," but Gray had already impressed upon his student the importance of systematic work and the role of flowering plants.[91] At Strasbourg, Farlow became familiar with morphology and with the development of fungi. At the conclusion of his stay in Europe, he returned to America as the only cryptogamic botanist in North America capable of conducting and teaching original work.

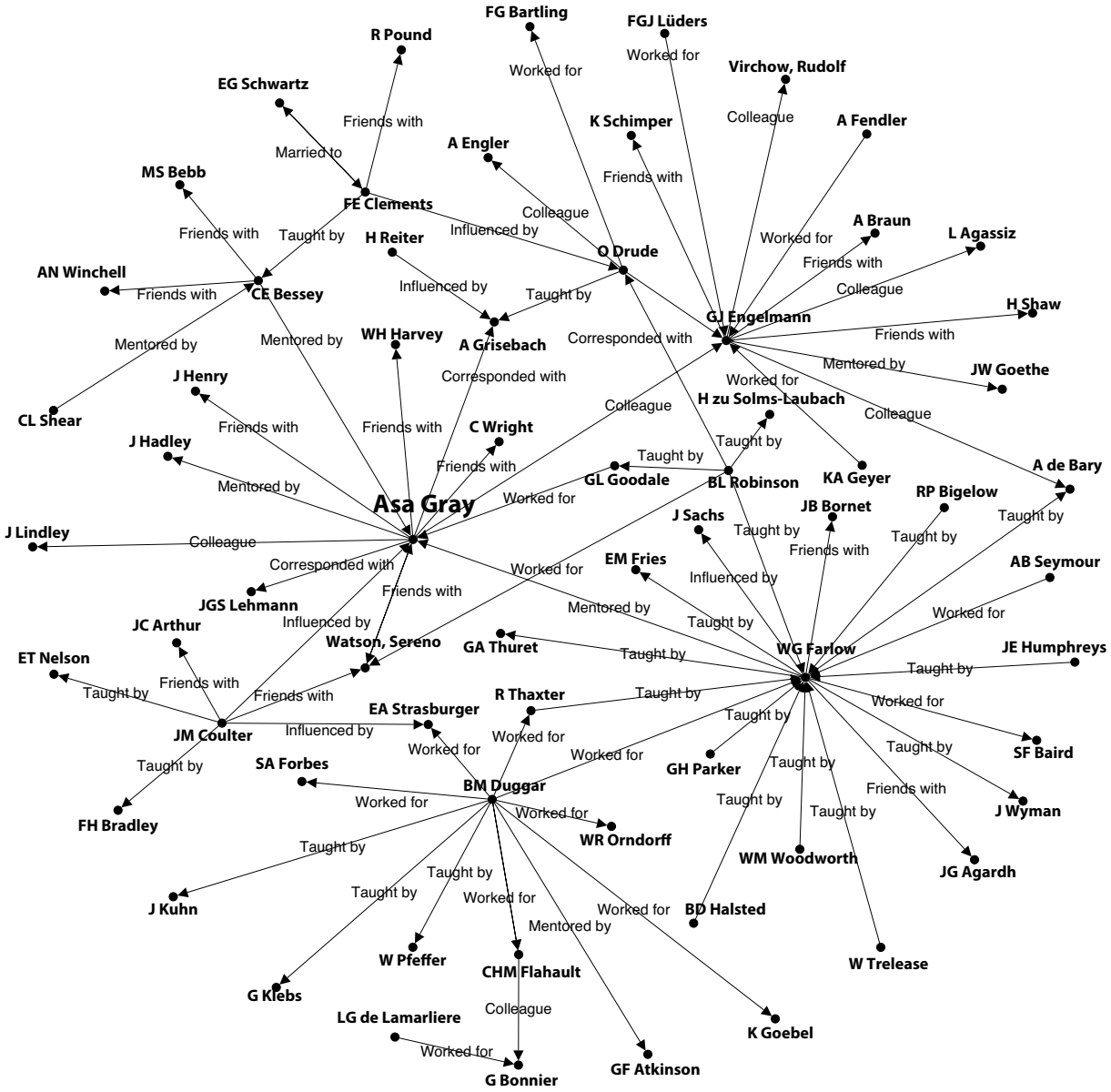

Figure 4.2. Asa Gray's impact on early ecology. For complete names, see the appendices.

91 *Ibid.*

Farlow taught at Harvard through the Bussey Institution for five years, where he became involved in establishing phytopathology studies in America, and then was transferred to Harvard where he published papers on potato rot, grape mildew, black knot, onion smut, gymosporangia, and fungous diseases of hollyhocks. He established a small private herbarium based on an acquisition of a fungi collection that had been arranged by Gray. Family money assisted him with the development of his collections and library. In all eruptions in the debates over nomenclature he would follow the lead of Gray and throw his powerful influence in favor of "sane and stable" methods for naming fungi, thus "helping to check the extreme radicalism of many American botanists, and preserving relations with the better men abroad."[92] Most of his fieldwork was in the White Mountains, but he accompanied Gray on a final journey to California in 1885. In 1888, Asa Gray passed away. Two years later, the Botanical Society of America was formed, which was an organization for professionals only and ended the perception of botany being part of the old grand network of natural history.[93] In 1892, when Sereno Watson was unexpectedly felled by the flu, young Benjamin Lincoln Robinson assumed the new Asa Gray chair at Harvard. Farlow and Robinson would be close allies safeguarding Gray's legacy for another generation. Both represented Harvard at the ICAS.

The middle phase of the early ecology network revolved around the species question. Understanding how organisms interacted first required a thorough understanding of the nature of species, a standardized system for naming species and crediting taxonomic work, and a working theory on a mechanism for the transformation of species. This research program was pursued by interested individuals from a wide variety of backgrounds, making progress mainly through true grit and a commitment to mobility. To obtain specimens, credentials, or professional connections, ecological thinkers had to stay on the move. Just as the basic concepts concerning historicized biology were agreed upon (or at least the diversity in opinion was established and recognized), the social climate shifted completely and professionalized, laboratory science became the norm. In response, ecologists themselves began to transform, eschewing the traditions of natural history and embracing the new, highly stratified environment of the university biology department.

92 *Ibid*., 489.

93 Keeney, *The Botanizers*, 37.

CHAPTER FIVE

1904: ECOLOGY BY ANY OTHER NAME?

American botanist Benjamin Lincoln Robinson had a knack for being the right man in the right place at the right time. The youngest son of a prominent Illinoian family, he graduated from Harvard at the age of twenty-three, married the daughter of a local lawyer, and immediately relocated his young wife to Germany so that he could pursue graduate studies in Strasbourg under the supervision of renowned biologist Hermann zu Solms-Laubach. When he returned to Massachusetts in 1889, he was an enthusiastic promoter of German culture, taking a position at Harvard teaching scientific German and also serving as assistant to botanist Sereno Watson, director of the Gray Herbarium, which was the premier institution in botany in the United States at the time.[1] The namesake for the herbarium, Asa Gray, had been a long-time associate of English naturalists Joseph Dalton Hooker and Charles Darwin and these connections, along with his exemplary career and considerable private financial resources, enabled Gray to establish a collecting institution in New England that compared favorably with those he regularly visited in Europe. Although Watson took the helm when Gray retired in 1873, he was a painfully shy individual and Gray remained active in botanical circles long into his retirement; the two worked in tandem until Gray's death in 1888. When Watson died suddenly of influenza four years later, it was Robinson who was perfectly positioned to take on the vacancy and continue the work of both men.

In 1899, Robinson became the first incumbent of the Asa Gray Professorship in Systematic Botany, a position established through a gift of Gray's widow, Jane. The new opening proved to be a rescue mission in disguise: Gray's monumental collections were languishing, overstuffed into an aging brick-and-wood structure within the botanical gardens, desperately in need of protection from fire and insects. By the time of Robinson's death, he had managed to sever the herbarium from the gardens, establish a permanent endowment, employ a small staff, move the collections into fire-safe containers, and edit and publish all of Gray's scientific volumes.[2] He had also taken upon himself a personal mission to solve the issue of nomenclature in biology, a conundrum reaching back to Gray's time and an ongoing irritation that he addressed during his speech at the International Congress of Arts and Science (ICAS) in 1904. In response, he was awarded a bronze medal for botany by the ICAS organizers.

---

1 Merritt Lyndon Fernald and Lily May Perry, *Biographical Memoir of Benjamin Lincoln Robinson, 1864-1935* (Washington, DC: National Academy of Sciences, 1937), 540. Fernald had been Benjamin Lincoln Robinson's assistant in the Gray Herbarium during his student years.

2 *Ibid*.

Figure 5.1. Benjamin Lincoln Robinson[3]

At the time of the ICAS, Robinson was preparing himself to represent his institution at the International Botanical Congress in Vienna. The remarks he made at each event confirmed that he was well-versed in both the current literature and the politics of professional botany. Robinson's commentary was retrospective in tone. He kept his remarks tightly bound to the mandate from the organizers to "unify knowledge" and to explain the progress of his field since 1803. He explained to the audience that when the United States had doubled its territory via the Louisiana Purchase, the nation simultaneously increased its physical and climatic diversity. "The newly acquired territory," he said, "contained wider prairies, higher mountains, greater forests, deeper gorges, and more arid plains than any east of the Mississippi."[4] He reflected upon the challenges that American explorers Meriwether Lewis and William Clark faced when probing the Missouri watershed, and lamented the "difficulties and with what devotion to science these plants were collected, prepared as scientific specimens, labeled, securely packed, and transported thousands of miles overland under circumstances which made each pound of baggage a source of untold labor and peril."[5] He then examined the development of botany from the days of Lewis and Clark, when it focused on classification, to its present state, which he described as being one of the "richest sciences in carefully observed and accurately recorded facts."[6] Robinson's view was that ecology was an approach or philosophy within biology, one that gained traction but had yet to reach its full potential.

---

3 Image from editorial on "The Progress of Science." *Popular Science Monthly* 66 (1904/5), 385. Photographer unknown. Public domain.

4 Benjamin Lincoln Robinson, "The Problems of Ecology," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance: 1908), 191.

5 *Ibid*., 192.

6 *Ibid*.

Daughter of Biogeography

Benjamin Robinson believed the ecological perspective could equally apply to plants and animals, but acknowledged that the approach was more evident in the plant sciences. His own preferred definition for ecology was borrowed from fellow speaker American botanist Charles B. Barnes, who referred to "that portion of the botanical science which treats of the relations of the plant to the forces and beings of the world about it."[7] Robinson claimed that the scope, significance and future of the field could only be understood through an examination of its origin and history. He viewed ecology as interdisciplinary and he thought that the boundaries between plant geography and ecology were especially complicated. Plant geography was closely allied with systematic botany, he clarified, and plant geographers created generalizations concerning the distribution of genera and species of plants. Plant geographers based their generalizations on ecological data but did not emphasize systematic relationships. By contrast, ecologists examined the relationship between plant structure and its activities, and then analyzed those activities against the external environment; they then made generalizations concerning distribution and the environment based on the structure of the plant. He could not resist noting that although the two approaches seemed have recently met in the middle, the ecologists had reached the middle in less time than the plant geographers had taken.

When reviewing the major influences on contemporary botany, Robinson, Drude, and their fellow speakers drew attention to individuals that worked on the species question in the 1850s. The influence of Darwin and his colleagues upon the botanists that attended the ICAS was obvious. While chairing the section on phylogeny, Barnes asserted that the "modern history of plant physiology begins shortly after the great impulse given to the study of nature by several contemporary events about the year 1860, the most notable of these being the publication of Darwin's *Origin of Species*."[8] Even so, according to Scottish botanist Frederick Bower, another generation passed before botanists appreciated evolution "as a factor in the morphology of the appendages."[9] In his speech, Bower sorted the development of plant morphology into phases,

7 *Ibid*., 193. Charles Barnes was from the University of Chicago, and served as Chairman of the Plant Physiology section on September 22.

8 Charles R. Barnes, "Plant Physiology." *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers. (London and New York: University Alliance, 1908), 101. The other major influence he cites is Julius Sachs.

9 Frederick Orpen Bower, "Plant Morphology" *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers. (London and New York: University Alliance, 1908), 62. Bower also emphasized the influence of Wilhelm Hofmeister's work in biology, along with the deep impact of Julius Sach's textbooks. John Merle Coulter similarly emphasized the widespread use of Sach's textbook in America, the work of Hofmeister, and the ongoing influence of Darwin's theory of natural selection. See John Merle Coulter, "Development of Morphological Conceptions," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers. (London and New York: University Alliance, 1908), 30.

much as Drude had sketched out for ecology. The two scientists suggested historical periods for botany that largely reinforced one another. Like Drude, Bower placed the middle phase for his discipline between 1840 and 1860.

The ICAS speakers demonstrated that botany and ecology in contemporary times (roughly 1895-1904) rested firmly on the research programs set out in the middle of the nineteenth century. New approaches were a direct result of the extraordinary impact of Darwin's *Origin*, as well as the publication of German botanist Julius Sachs' textbook, *Experimental Physiologie der Pflanzen* (1865). Speaking in the section on plant physiology, Austrian botanist Julius Wiesner described Sach's textbook as a summary that "rocked the world" credited the ripple effect of both Sachs' and Darwin's works.[10] Wiesner referred to the work conducted during the mid-century as a "most seasonable undertaking" that directly furthered the development of plant physiology. In the same vein, Drude recalled that his mentor, German botanist Augustus Grisebach, developed a doctrine that climate found expressions in formations composed of vegetation in the 1850s.[11] Drude also drew attention to German geographer Moritz Wagner's work between 1836 and 1853, which had attempted to extend questions of theoretical evolution so as to include the problem of the distribution of species, although he cautioned against assuming that Wagner anticipated natural selection, noting that in Wagner's day species were still regarded as something fixed and unalterable. During the same period, vast amounts of data were collected and worked over not only by Darwin and his circle, but also by Hermann Müller, Johann Hildebrandt, and other German botanists and geographers who "gave a great impulse" to new kinds of research and so "knowledge of the evolution of the earth and of organic species" became the aim for the first time.[12]

The various ICAS speakers differed somewhat on the role of laboratory methods in botany and ecology. Drude remarked that within floristics numerous attempts had been made to correlate organs with the environment by borrowing methods from experimental physiology.[13] In Drude's view, the laboratory experiments of physiology were not fundamentally different for ecologists but simply occurred outdoors, "where the changing play of nature's focus could be observed and

10 Julius Wiesner, "The Development of Plant Physiology," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers. (London and New York: University Alliance, 1908), 110.

11 Oscar Drude, "The Position of Ecology," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers. (London and New York: University Alliance, 1908), 181. Grisebach later released a textbook summarizing his life's work: *Die Vegetation Der Erde Nach Ihrer Klimatischen Anordnung: Ein Abriss Der Vergleichenden Geographie Der Pflanzen* (Leipzig: Engelmann, 1872). Drude defined a formation as plants that had similar requirements, and included North American vegetation such as the cactus and Canadian tundra in his examples.

12 *Ibid*., 182.

13 Drude, "The Position of Ecology," 181.

fresh data obtained, which later could serve as a basis for further experiments in the laboratory."[14] By contrast, Robinson argued that advances in the laboratory techniques were vital for botany, although he also cautioned that plant physiology was "as far removed from ecology as human physiology is from sociology."[15] When Robinson discussed the changes that occurred in the field in response to Darwin's work, he described a "feeling" that arose almost simultaneously in several areas of life science that anatomy must be physiologically interpreted, based on laboratory studies that had observed and named processes and forces as they occurred in nature. This feeling actually signaled the birth of a new field in science, ecology. His reference to terminology placed this development in the late 1860s. Drude and Bower, by contrast, identified the new phase in the 1880s, when the focus in botany permanently shifted. Drude described how only at that point the understanding of pollination had fundamentally changed. Biological relationships between flowers, wind, and the insect world suddenly became important enough to be included in the science of botany. He said that for the first time the mutual dependence of the animal and plant kingdoms in their household economy became clear, and botanists began to consider how these factors contributed to the struggle for existence.[16]

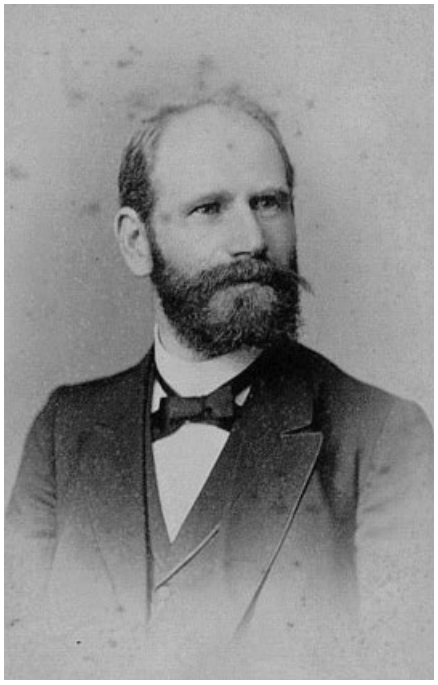

Figure 5.2. Oscar Drude[17]

14 *Ibid*., 178.

15 Robinson, "The Problems of Ecology," 194.

16 Drude, "The Position of Ecology," 182-3.

17 "Carl Georg Oscar Drude." University of Coimbra Digital Library website. Accessed September 15, 2016. Available at https://digitalis.uc.pt/en/fundo_antigo/carl_georg_oscar_drude. Photograph by A. Adler. Full access.

Drude and Bower agreed that by the end of century, widely separated branches of science were brought together in order to explain the life-history of a certain region. Botanists collaborated with other disciplines in order to comprehend the division of entire continents into zones. The disparate elements came together to form "a new entity," Drude asserted, which was ecology.[18] Drude spoke of ecology as being the "daughter of biogeography," a younger generation who would soon destroy her mother's reputation and eventually take her place.[19] Despite this fanciful turn of phrase, Drude was not Romantic in nature. He was a scientist and a public servant. Neither was he an ivory tower academic: rather, his work was thoroughly integrated with applied applications for his field of study and he consistently proved to be open to working with other scientific disciplines, with professional agriculturalists, and with amateur naturalists. Drude embraced both inventory science and analytical studies, as both could contribute to the wider base of knowledge. In his speech at the ICAS, he indicated that large amounts of data had been amassed and needed to be analyzed. In particular, he emphasized that the ecologist who took on this challenge required a first-rate education, an interdisciplinary disposition, and the latest methods and equipment in order to tackle the challenges ahead. Unfortunately, while botanists were making great strides, many zoologists and palaeontologists remained mired in controversy about Lamarckism, the idea that an organism might pass on characteristics that it has acquired during its lifetime to its offspring.

Ethologie and Lamarckism

Darwinists came from a variety of intellectual backgrounds, and showed diversity in their level of adherence to Darwin's theories. Historian Thomas Junker has summarized how Darwin presented his theory as a unified concept in the *Origin* and spoke of it in the singular, but individual elements were soon isolated, criticized and accepted independently.[20] Many biologists accepted the idea of gradual change of species over time, but rejected natural selection. Junker recapped ornithologist Ernst Mayr's identification of five major theories in Darwin's work: evolution as such; common descent; gradualism; multiplication of species; and natural selection. He added a sixth: the origin of hereditary variation. Junker promoted variation as an absolutely crucial prerequisite for the theory of selection, since without variation there can be no selection. Darwin devoted a significant portion of the *Origin*, and other works, to the subject of variation, but before 1890 knowledge of the laws of inheritance was not widespread and many of Darwin's contemporaries accepted the inheritance of acquired characteristics (Lamarckism).

---

18 Drude, "The Position of Ecology in Modern Science," 182.

19 *Ibid*.

20 Thomas Junker, "Ornithology and the Genesis of the Synthetic Theory of Evolution," *Avian Science* 3 No. 2/3 (2003), 67.

One prominent Lamarckian that spoke at the ICAS was also an ecological thinker. French zoologist Alfred Giard was a global authority on evolutionary biology who originally hailed from Valenciennes. He had been appointed professor of natural history at the *Université Lille Nord de France* more than three decades previous, when "natural history" was already an anachronistic term.[21] Giard updated the department, launching a zoological centre as well as a marine station at Wimereux near Boulogne. In 1887, he accepted a position in Paris at the *École Normale Supérieure*, and within a year was awarded a professorship at the Sorbonne. Like many biologists of his generation Giard believed in Lamarck's theory of "soft inheritance," a notion that Charles Darwin himself abhorred and German biologist August Weismann had already proven impossible through theoretical and experimental arguments.[22] The new Lamarckians nevertheless felt they were complementing and completing Darwin's theory on natural selection.[23] By 1890, Giard had established an institute for the continuing study of the mechanisms of heredity and transformation. His university lectures typically reviewed the history of evolutionism and defended the possibility of many non-Darwinian mechanisms. His ideas were well received in the scientific world: *Nature*, the most prominent scientific publication at the time, published a translation of a complete Giard lecture in 1891. As historian Michel Morange has discussed, however, Lamarckism was a complete failure and in his opinion its popularity delayed the development of a genetics program in France.[24] Eventually Giard would concede that he and his colleagues had been unable to prove a mechanism for soft inheritance.

Giard was a leading light within zoology and his invitation to the ICAS reflected his academic and social position. He was placed not in ecology but in the animal morphology session, and this choice was probably for the best since the ecology session featured orthodox Darwinists. He was expected to discuss pure morphology and evolutionary theory, topics on which he had published widely on. When Giard passed away, his speech at St. Louis was specifically mentioned in the obituary penned by Maurice Caullery of the University of Paris. Caullery, who was then an exchange professor with Harvard, remembered him demonstrating "an unusual degree of knowledge of infinite details of nature and of general philosophy."[25] Giard was an expert in

21 Raf De Bont, *Stations in the Field: A History of Place-Based Animal Research, 1870-1930*. (Chicago: Chicago University Press, 2015), 83-85.

22 A revival of Lamarckian ideas emerged in the 1890s, although there were several variants. In Britain, biologist and social theorist Herbert Spencer rejected August Weismann's evidence against inheritance of acquired characteristics as a motor of organic evolution. In France, Giard praised British naturalist George John Romanes for accepting theories other than natural selection, and condemned Weismann for being dogmatic. See discussion in Alexander Vucinich, *Darwin in Russian Thought* (Berkeley: University of California, 1988), 156-65.

23 Michael Morange, "What History Tells Us: XXII, the French Neo-Lamarckians," *Journal of Biosciences* 35, no. 4 (2010): 516.

24 *Ibid*., 515.

25 Maurice Caullery, "Professor Alfred Giard (1846-1908)," *Science* 29, no. 732 (1909), 71.

zoology, but he was also well-known as a leader in a French Lamarckism revival and a promoter of a new approach in understanding the relationship between organisms, *ethologie*. Historian Alexander Vucinich has pointed out that Lamarckism was also widely evident in Germany.[26] These ideas were known variously as *ethologie*, *bionomics,* and *oekologie*. They can re-conceptualized as scientific networks, with ecology being pursued in Anglo-American work, in Scandinavia, and in Germany.[27] In France, these ideas were investigated as *ethologie*, which Giard embraced. Raf De Bont suggested that Giard's philosophy of *ethologie* constituted a scientific attitude that was found not only in France but across the Anglo-American scientific circles as well as in Scandinavia and Germany. *Ethologie* could then be understood as the French network of scientists interested in ecological thinking, or even more simply as a cluster of ecological thinking that existed within the larger international network.

Figure 5.3. Alfred Giard[28]

26 Vucinich, *Darwin in Russian Thought*, 158-9.

27 Nineteenth century bionomics should not be confused with a contemporary notion of bionomics that attempts to reconfigure economics as an ecosystem. Bionomics, translated from the French term *bionomie.*

28 Editorial. "The Progress of Science." *Popular Science Monthly* Vol. 74 (May 1909), 519. Photographer unknown. Public domain.

Giard's Lamarckism cannot be fully disconnected from his idea of *ethologie*.[29] At his home institution Giard did not make any attempt to separate his expertise in animal morphology from his interest in *ethologie*, but in his speech at the ICAS Giard was sly about introducing the latter concept. He opened by discussing French physiologist and vivisectionist Claude Bernard lecutring at the Universal Exposition of Paris in 1867, drawing attention to Bernard's attempt to divide the sciences into those concerned with "contemplation and observation," such as astronomy, and those that were active "nature-conquering" sciences such as physics, chemistry and physiology. This construct was a straw man that Giard was prepared to slay, for laboratory-based scientists like Bernard were quick to disparage field biology for being one of the former observational sciences. He and his fellow ethologists objected to the insult and argued that true innovation required a generalist approach: "The naturalist is the describer; the physiologist is the creator" he said in his speech, but a question mark was implied.[30] Giard was critical of Bernard's stance, and he and his pupils continued to revere the "real naturalist" and mocked the stereotypical microtomist who they depicted as only visiting the countryside on raiding expeditions.

Giard similarly was disdainful of the remnant of naturalists that adhered to the outdated doctrines of naturalists Georges Cuvier and Richard Owen, both of whom believed that species were immutable. Giard asserted that discerning how species were formed was more important than describing an individual specimen in its adult state, and he rejected naturalists that were "content to catalogue and to compare among themselves, after the fashion of a collector of arms or of objects of art, some of the many forms whose astonishing variety they admire as the fruit of the inexhaustible imagination of an infinitely ingenious Creator."[31] He allowed that descriptive work as an important cornerstone of science, but he believed that the "vast laboratory of nature" was full of possibility for "natural experiments."[32] Eschewing the natural theology favored by creationists, Giard told his audience that whatever the method employed, "be it deduction or induction, observation or experiment, anatomy, physiology, ethnology, geonomy, taxonomy, palaeontology," all biologists

29 Vucinich, *Darwin in Russian Thought*, 158-9. See also Morange, "What History Tells Us," where the author supports historian Laurent Loison's recasting of the Lamarckian movement in France as a dynamic scientific movement rather than an intellectual dead end. Raf De Bont similarly argues that Giard's methodological stress on the importance of the environment arose from his belief that individual adaptation played a crucial role in evolution. Raf De Bont, "Organisms in Their Milieu: Alfred Giard, His Pupils, and Early Ethology, 1870-1930," *Isis* 101, no. 1 (2010), 1-29.

30 Alfred Mathieu Giard, "The Present Tendencies of Morphology and Its Relations to the Other Sciences," *International Congress of Arts and Sciences* 9. Ed. Howard Jason Rogers (London and New York: University Alliance, 1908), 259.

31 *Ibid*., 264.

32 *Ibid*., 17.

should attempt to trace the history of all manifestations of life upon our planet.[33] He reminded the audience that in 1877 German biologist Ernst Haeckel had proclaimed that the theory of descent was pivotal, providing biological sciences with a new, single, unified perspective.

Giard went on to define his own approach, *ethologie*, as the science that dealt with the habits of living beings and their relations—a definition that strongly resembles the modern view of ecology. Giard's definition of *ethologie* was also similar to Haeckel's initial definition of *oekologie*, the science of the relationship of the organism with the environment, including in a broad sense all the conditions of existence.[34] This interpretation differed somewhat from the description of ecology that botanist Oscar Drude had provided in the ecology session, where the new discipline referred to geographer Friedrich Ratzel and was presented as "an investigation into the vital phenomena exhibited by plants and animals in the struggle for space, under conditions provided by the climate and physiography of a country."[35]

English, French, and German interpretations of Darwin's thesis were inextricably mixed with the establishment of ecology. Anglo ecologists had a closer link with both Darwinism and social Darwinism. Yet they were both movements that developed during the period in which the sub-disciplines of field biology were not yet crystallized. The notion of competing networks is more questionable. Historian Laurent Loison and Michel Morange emphasized that Giard maintained connections with scientists working in foreign countries.[36] Giard himself considered the German *oekologie* and the British term *bionomics* as foreign variants of his own French *ethologie*.[37]

In his speech at the ICAS, Giard argued that biology could only be innovative when it was general and complete; he was critical of the trend towards specialization. Ethologists valued encyclopedic knowledge, meticulous observation, and patience. They believed that interdisciplinary thought led to progress.[38] Within Giard's personal network, ecological thinkers came from a number of disciplines, including zoology, botany, palaeontology, sociology, museology, and agronomy. The most important figures in his circle were French biologists Jules Bonnier, Georges Bohn, Casimir Cépède, and Étienne Rabaud, along with Jean Massart and Louis Dollo from Belgium.[39] Their main publishing outlet was Giard's own *Bulletin Scientifique de la France et de la Belgique*,

33 *Ibid*., 261. Haeckel's remarks were made at a congress of physicians and naturalists in Munich.

34 De Bont, "Organisms in Their Milieu," 2.

35 Drude, "The Position of Ecology," 179.

36 Laurent Loison, "French Roots of French Neo-Lamarckisms, 1879-1985." *Journal of the History of Biology* 44, no. 4 (2011), 713-44; Michael Morange, "What History Tells Us: XXII, the French Neo-Lamarckians." *Journal of Biosciences* 35, no. 4 (2010), 515-7.

37 Giard, "The Present Tendencies of Morphology," 5.

38 De Bont, "Organisms in Their Milieu," 8.

39 *Ibid*., 5.

and the bulk of their investigations were conducted at Giard's marine station in Wimereux. Giard's work was heavily influenced by the school of evolutionary morphology established by Ernst Haeckel and anatomist Karl Gegenbaur at the University of Jena in the 1860s.[40] Giard and his circle investigated specific types of evolutionary adaptation, such as mimicry, and they became particularly well-known for their work with parasites, where they conceived innovative studies that treated the host as the "environment."[41] The francophone ethologists also sought opportunities in applied science through partnerships with the French government. Giard himself was a member of several governmental commissions, where he published on agronomy, overfishing, and the possible use of parasites to biologically castrate insects.[42]

De Bont argued that the appearance of French *ethologie* reflected a critical shift in scientific attitude that occurred in the laboratory, the museum, and the zoo, and eventually "triggered a reappraisal of fieldwork."[43] His work makes it clear that the French *ethologie* has been underrepresented, and De Bont states that this omission is because French-speaking work is generally neglected in the history of the science, which has focused on the Anglo-American world, Scandinavia, and Germany.[44] There was an upsurge in interest concerning the interactions between organisms and their environment by 1900 in these same scientific circles. The interconnections between the nodes of study were not well forged, and the various clusters showed critical differences. Giard was one of the few scientists, for example, that still allowed a place for amateurs and local knowledge at the turn of the twentieth century.[45]

The foreign correspondents of French ethologists were not necessarily cognizant of the differences in perspective. De Bont has argued that naturalists were pleading for a reappraisal of field biology, but lacked coordination.[46] When biologist Frederick Dahl, for example, attempted to bring the term *ethologie* into German science, he defended its use by suggesting that *ethologie* was simply ecology investigated on an experimental basis.[47] On the other hand, in the United States American zoologist William Morton Wheeler took up the cause of *ethologie* in order to disassociate

40 *Ibid*., 8. The term *ethologie* was first coined by the Parisian naturalist Isidore Geoffroy Saint-Hilaire. It was derived from the Greek *ethos* (habit) and *logos* (knowledge).

41 Giard, 266; see also De Bont, "Organisms in Their Milieu," 9.

42 *Ibid*., 11.

43 *Ibid*., 1. See the abstract De Bont provides.

44 *Ibid*., 2

45 Morange, "What History Tells Us," 516.

46 De Bont, "Organisms in Their Milieu," 4 and 28.

47 *Ibid*., 7.

himself from ecologists that he believed were in fact botanists focused on plant geography.[48] Wheeler's bid was unsuccessful, and his colleagues Victor Shelford and Charles Adams used "animal ecology" instead.[49] Shelford and Adams also expressed concern that structural adaptations were being applied as a basis for ecology, and hypothesized that animal species may actually appear in one place and find their way to appropriate environments.

Lamarckism was not only present in France and Belgium. Beginning around 1880, a key group of American biologists and palaeontologists argued that all organisms were in continual transformation, so species could be considered nothing more than an arbitrary marker along a continuum.[50] This group recast the evolution of animals into a narrative that was intended to resist the anti-Creationist rhetoric of Darwinism. Their research program was also distinctly unlike the holism preferred by French ethologists, since they instead emphasized that the evolutionary adaptation of organisms might progress in a goal-oriented fashion.[51] Eventually, the neo-Darwinian view of speciation would become the conventional explanation for professional ecologists throughout the network.[52] It was not a straightforward path, however, due to pervasive interference from creationists and multiple Lamarckian revivals.

Experimental Natural History

In the section on phylogeny at the ICAS, chairman Thomas Hunt Morgan of Columbia University introduced the keynote speaker, Dutch geneticist Hugo de Vries. Morgan claimed that evolution no longer referred only to a historical method in biology, but to a process that occurred in the present, largely due to the work of their famous guest.[53] In his speech, Hugo de Vries focused on the more negative aspects of Darwin's theory and described natural selection as involving the "sifting out of all those of minor worth through the struggle for life," proclaiming this truth as "one

48 *Ibid*.

49 *Ibid*.

50 Martin J. S. Rudwick, *Bursting the Limits of Time: The Reconstruction of Geohistory in the Age of Revolution* (Chicago: University of Chicago, 2005), 388.

51 Morange, "What History Tells Us," 516.

52 Robert McIntosh, *The Background of Ecology: Concept and Theory* (Cambridge, UK: Cambridge University Press, 1985), 34-9.

53 Thomas Hunt Morgan, "Phylogeny," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (St. Louis: University Alliance, 1908), 27. Morgan favored the experimental method over field study, and laughingly endorsed Whitman's breeding experiments on European pigeons and De Vries' studies of the American plant in *Enothera Lamarckiana* as evidence that "political boundaries disappear before the advances of the sciences." Morgan would go on to conduct his own famous study of mutation in flies in a laboratory setting.

of the great principles that rule the evolution of organisms."[54] Natural selection could not cause improvement, he cautioned, and its only function was to decide what survived, keeping evolution "on the main lines" and destroying "nearly all that try to go in other directions."[55] His fellow speaker was American zoologist Charles Otis Whitman. Whitman was more positive in tone, and focused on how Darwin inquired into the patterns in pigeons as part of his investigation into the origin of species, on the understanding that the process that developed in one characteristic should be the same for change within a species as a whole.[56] Whitman argued that studies of favorable characteristics led to definitive conclusions concerning the species question.

A review of the speech provided by conservationist Joesph Grinnell in *The Condor* complimented Whitman's ability to explain the difficult concepts and applauded his efforts to encourage young ornithologists in their chosen field.[57] This would have been welcome praise, since Whitman spent his early career seeking a way to turn his youthful obsession with bird collecting into a viable profession. By 1904, he had obtained a PhD from Leipzig University, studying under zoologist Rudolf Leuckart, and had amassed numerous teaching credentials from the eastern seaboard to the Imperial University of Japan. He was an expert in morphology and his international studies had provided him with a detailed understanding of the current literature and available specimens—what one biographer termed "a German type of mind."[58] He attended the ICAS representing the University of Chicago, and was asked to summarize the foremost issue in phylogeny. In response, he claimed his current focus was the same as the "life-work of Charles Darwin, and which cannot be better or more simply expressed than in the title of his epoch-making book, *The Origin of Species*."[59] Whitman used the speaking engagement as an opportunity to promote his recent establishment of an outdoor experiment station and champion the new "experimental natural history" he was conducting, contrasting it with the narrower, physiological, laboratory-oriented approach of his University of Chicago colleague, physiologist Jacques Loeb. The problem with Loeb's approach, Whitman complained, was that it reduced instincts to nothing other than heliotropisms and stereotropisms in such a way that "the whole course of evolution drops out of sight altogether, and things are explained as if the organic world were a chemical

54 Hugo de Vries, "A Comparison between Artificial and Natural Selection," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York: University Alliance, 1908), 28.

55 *Ibid*.

56 Charles Otis Whitman, "The Problem of the Origin of Species," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York: University Alliance, 1908), 47.

57 Joseph Grinnell, "Review: The Problem of the Origin of Species," *The Condor* 9, no. 1 (1907), 30-1.

58 Edward Sylvester Morse, *Biographical Memoir of Charles Otis Whitman, 1842-1910* (Washington, DC: National Academy of Sciences, 1912), 278.

59 Whitman, "The Problem of the Origin of Species," 41.

creation only a few hours old."[60] Whitman's remarks on the future of the field were circumspect and he did not discuss the considerable hurdles he faced in obtaining resources for his studies, a negligence derived from university administrators' preference for traditional indoor laboratory studies.

Summarizing the history of phylogeny, Whitman emphasized the enormous influence Darwin had on "every field of thought" by providing the theory of natural selection and removing the need for a supernatural explanation to account for the origin of species. He considered it a campaign so successful that the old belief "was certainly effectually exploded, and is now passing into oblivion."[61] He also provided a condensed explanation of two prevailing alternative theories of evolution: orthogenesis, or directed variation; and mutation, variation through sudden leaps forward. Whitman immediately dismissed the idea of orthogenesis for rejecting Darwin and suggesting that organisms inherit acquired characteristics. He then carefully flattered his fellow speaker Hugo de Vries on his well-regarded experiments on mutation, but questioned whether all species could have been created by sudden so-called "saltations." Whitman was not seeking conflict or controversy, rather he was suggesting that a multiplicity of variations was possible. He anticipated a synthesis occurring that would include the best aspects of the concepts of orthogenesis, mutation, and natural selection.

Whitman favored the primary influence of natural selection and endorsed German evolutionary biologist August Weismann's criticism of mutation, but he worried that many sense-organs could not be traced to a rudimentary form. He reminded the audience that Darwin himself had similar concerns and cited a letter Darwin wrote to Asa Gray regarding orchids: "It is impossible to imagine so many co-adaptations being formed, all by a chance blow."[62] For the rest of his speech, Whitman succumbed to the temptation to dwell on his work in progress, and detailed the variations of pigeons he had studied and speculated as to their origins. His early remarks, however, demonstrate his familiarity with the work of Darwin, Weismann, Gray, and de Vries, and his participation in a trading network of ornithological collectors. He was a prime example of an ecological thinker: he was studying organisms in their environment, and organisms relating to one another.

Whitman's efforts to conduct the ultimate study of pigeons would become quixotic. When his attempt to keep his research farm isolated from the public was overruled by the administration, he set up a research site at his home. He and his wife cashed in their life insurance policies to pay for the equipment necessary to maintain and study Whitman's collection of pigeons (550 individuals,

60 Richard W. Burkhardt (Jr), "Ethology, Natural History, the Life Sciences, and the Problem of Place," *Journal of the History of Biology* 32, no. 3 (1999), 495.

61 Whitman, "The Problem of the Origin of Species," 42.

62 *Ibid*., 46.

30 different species). Having created his ideal work environment, he avoided appearing at the university and became wholly focused on gathering data, intending to write the definitive analysis of pigeon behavior, including a summary on heredity and evolution.[63] In December of 1910, a cold wave hit Chicago and Whitman caught a chill while moving his beloved birds into their winter quarters. This illness developed into pneumonia and he died without completing his monograph. His greatest contribution to science was his formulation of the idea that instinctive behavior patterns can be used in reconstructing phylogenies.[64] His most importance influence was Darwin.

Whitman and de Vries both accepted natural selection, although they differed on its potential application in experimental biology. Whitman argued that Darwin had "banished" teleology from biology, while in the Plant Physiology section Julius Wiesner mused that Darwin's theory *should* have eliminated teleology in biology but did not succeed.[65] Wiesner expressed gratitude for this failure because he believed that science was advanced through the investigations into the purposes of organs, and that interdisciplinary discussions between biology and philosophy had often proven useful.[66] The pairing of teleological biology and philosophy, however, seemed to create a drumbeat for the slow and steady march through social Darwinism and on to the breeding programs of the twentieth century. One the foremost advocates of eugenics would be American zoologist Charles Benedict Davenport, who also attended the ICAS in 1904. Davenport commented on Darwin's doctrine in the animal morphology section. Davenport was less interested in the "survival" part of the equation, and more in pairing the "fit" with the best possible environments. He recalled that before Darwin, English ethnologist James Cowles Prichard had promoted the idea that the Creator placed species in the habitats that would best suit them; he in turn suggested a theory of segregation where species changed and dispersed until they find a place suited to them.[67] He described the ability of the English sparrow to thrive in the Americas, deliberately implying it was a metaphor for European humans similarly colonizing North America.

Darwin's influence was apparent in a variety of speakers at the ICAS. These individuals had strikingly different political perspectives, ranging from the racist bias evident in Davenport's

63 *Ibid*., 496-7.

64 *Ibid*.

65 Wiesner, "The Development of Plant Physiology," 119. He quotes from M.J. Schleiden, *Grundzüge Der Wissenschaftlichen Botanik Nebst Einer Methodologischen Einleitung Als Anleitung Zum Studium Der Pflanze* (Leipzig: W. Engelmann, 1842). Teleology refers to the tendency to explain the evolution of organs as occurring for some purpose.

66 *Ibid*.

67 Charles Benedict Davenport, "Animal Morphology in Relation to Other Sciences" *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers. St. Louis: University Alliance, 1908), 250. Davenport is well-known for his voluminous output of work against race crossing, and his long-term correspondence with Nazi scientists in Germany.

work to the carefully tempered commentary from German-American anthropologist Franz Boas, who warned the audience about the dangers of misapplying the lessons of evolution to human society.[68] There was no consensus in biology about how to apply Darwin's theory within science. Giard claimed in the morphology section that in 1859, "the state of the physical and chemical sciences did not permit a successful approach to most of the problems of external physiology" and suggested that ever since that point, the ideas of Darwin had been embraced by some and contorted by others.[69] Whitman, for his part, thought Darwin's solution was incomplete, and since 1859 the problem of species had grown larger rather than smaller with each new proposed solution.[70] Most scientists at the ICAS accepted the theory of natural selection. Some desperately wanted to be able to take it further. Many thought the best way forward was in the laboratory, by isolating and focusing on the transmutation of a single organism. Embryologist William Keith Brooks explained:

> *We speak of the struggle for existence; but my struggle has not been like yours, and the struggle for existence is only a formula. Species have come about according to, but not because of or by means of, the principle of the survival of the fittest, for a formula can do nothing. The fitness of living beings is not ideal or abstract, but private and particular.*[71]

Darwin's work remained both leading edge and controversial a half century after the publication of the *Origin*.

According to historian Richard Burkhardt Jr., the struggle between the morphologists and the experimentalists in zoology was an important episode in the history of the life sciences. He contrasted the bitter spats from this conflict with the relatively convivial relationship between field biologists and "cabinet" or museum naturalists in botany, which remained largely symbiotic.[72] Burkhardt believed the most innovative work in animal behavior and adaption during this period was being performed by Whitman. He lamented that Darwin's publications had not inspired more zoologists to spend time in the field observing living animals. Rather, by the turn of the twentieth century, field naturalists and academic zoologists were distinct types.[73]

---

68 Franz Boas, "The History of Anthropology," *International Congress of Arts and Science* 10. Ed. Howard Jason Rogers (London and New York: University Alliance, 1908), 471. Boas was trained in biology and history, as well as anthropology.

69 Giard, "The Present Tendencies of Morphology," 273.

70 Whitman, "The Problem of the Origin of Species," 42.

71 William Keith Brooks, "Individual Development and Ancestral Development," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 317.

72 Burkhardt, "Ethology, Natural History, the Life Sciences, and the Problem of Place," 490.

73 *Ibid*., 494-5.

Fratricidal Disputes

Ecology looked at the relationship between organisms, both spatially and historically, and palaeontology could furnish evidence for these relationships. Its influence on life science was recognized by Giard when he remarked that palaeontology provides "experimental data of incalculable value." Unlike ecology, however, palaeontology was not included with the life sciences at the ICAS. Under Hugo Münsterberg's schematic it was scheduled with the earth sciences. American geologist William Morris Davis, proclaimed the primacy of the earth sciences above all other science in North America, and argued for the vital importance of geological research. He insisted that:

> *nowhere is the orderliness of geological changes better attested than in the forms of ridge and valley seen today in various examples, young and old, of the wasting mountain ranges themselves, and in the systematic adjustment that is attained by the drainage-lines with respect to the structures of which they work. Here indeed is cumulative testimony for uniformitarianism; for nothing but the long persistence of ordinary processes can account for these marvellous* [sic] *commonplaces.*[74]

Yet Davies also connected geological study to the ongoing evolution debates. He emphasized "evolution is a term of broader meaning" and most scientists were "glad to replace the violent revolutions of our predecessors with the quiet processes that evolution suggests."[75] He suggested that geographers "may share its use with the biologists."[76]

Geology can be viewed as the figurative and literal bedrock upon which theories of evolution were founded. The work of geologists provided fundamental concepts for the steady and branching evolution of species, including James Hutton's studies on the geologic scale of time, and Charles Lyell's theory of uniformitarianism. The roots of ecology could be found as much in the rocks and fossils of early earth studies as in the life systems analyzed by those in the Humboldtian tradition. Arthur Smith Woodward, Keeper of the British Museum's geology department, explained during his talk in the palaeontology section at the ICAS that the interpretation of fossils required so much detailed knowledge from a variety of disciplines that it is usually included as a part of geology, but has sometimes been associated with zoology or comparative anatomy in university departments.[77]

---

74 William Morris Davies, "The Relations of the Earth Sciences in View of the Progress in the Nineteenth Century," *International Congress of Arts and Science* 8. Ed. Howard Jason Rogers. (London and New York: University Alliance, 1908), 496.

75 *Ibid.*

76 *Ibid.*

77 Arthur Smith Woodward, "The Relations of Palaeontology to Other Branches of Science," *International Congress of Arts and Science* 8. Ed. Howard Jason Rogers. (London and New York: University Alliance, 1908), 551.

He was tasked with explaining the role of palaeontology as a separate discipline within the earth sciences, despite the fact his preference was to see the study of ancient life forms associated with the rest of life science in the biology section.[78] Woodward was a Darwinist, and argued that the fossil record supported the theory that species originated once, from one set of ancestors.[79] The explanation he provided to the audience assumed they possessed a basic understanding of Darwinian concepts:

> *Palaeontology justifies the assumption that each type of animal or plant has only originated once and from one set of ancestors. Fossils can therefore be used as an aid to the solution of geographical problems. If a more or less sedentary group of animals is found to be essentially identical in two widely separated seas, it may be reasonably assumed either that those seas were once connected, or that they received their life from a common source. Similarly, if two distant tracts of land are inhabited by the same animals and plants, and there is no possibility at present of migration between these two regions, a former connection either with each other or with a common centre may also be postulated.*[80]

His example of this phenomenon was *Mollusca* living on opposite coasts of the Bering Strait: the living specimens have distinct differences, but fossil evidence shows they were nearly identical during the Pliocene period. Therefore, the fossil evidence supports the idea that the coastline was continuous at that time, and as he summarized "the ultimate separation of the so-called Old and New Worlds is shown by fossils to be quite a modern event in geological history."[81] In this way, palaeontology could contribute to the study of the relationship between organisms. As has already been discussed with zoology, within American palaeontology at the time there was also a clear split between Lamarckians and Darwinists. The French natural philosopher Jean-Baptiste Lamarck had been a botanist turned invertebrate specialist, but he also maintained a keen interest in fossils, which he described as "extremely precious monuments of the state of the revolutions that different

78 *Ibid*., 558.

79 *Ibid*., 555. Woodward's acceptance of the principle that species could originate only once would lead him into trouble when he later was duped by a hoaxer and subsequently associated with the notorious Piltdown Man incident. Several humanoid skull pieces were found in an English quarry and assembled with unrelated other remains and then presented as the original ape-man. The culprit is assumed to be amateur Henry Doyle, who may have been inspired by a similar hoax performed by Charles Waterton a century earlier.

80 Woodward, "The Relations of Palaeontology," 555. Woodward was a proponent of a radical Victorian biogeographical theory that life began in the northern regions of the world. While the Bering Strait theory had reached a near-consensus in scientific circles by 1904, it was still unclear whether species only moved westwards, or if there was a species exchange.

81 *Ibid*.

points on the surface of the globe have undergone" and contained traces of "the changes that living being have themselves successively experience there."[82]

The split between Lamarckians and Darwinists in palaeontology was pantomimed in the so-called "bones war" that occurred between the palaeontologists Othniel Charles Marsh, who was one of the first to speculate on the origin of bird species, and Edward Drinker Cope, a wealthy independent scholar. Marsh came from a modest background but was able to pursue advanced studies through the financial support of a wealthy uncle. Marsh attended Yale University, travelled to England in 1862 to work with Charles Lyell and Thomas Henry Huxley, and then finished his education at the University of Berlin. He met Cope for the first time in Germany, and took an immediate dislike to the former child prodigy. Cope had not sought formal schooling after the age of sixteen but had nevertheless already authored dozens of scientific papers. Marsh (unlike Cope) accepted Darwinian evolution as fact.[83] He took a position as professor of palaeontology at Yale in 1865, solidified his career with pioneering work done on fossilized horses, publishing a paper that greatly impressed his former teacher Huxley, and by 1872 had proposed that birds and reptiles had common ancestors in the dinosaur age.[84] A series of disputes between Marsh and Cope began when Marsh noticed Cope set a piece of a specimen on the wrong end in a display. Their "war" reached its peak in 1890 when a spirited exchange between the two dinosaur hunters was published in the newspapers. Marsh "won" the war on several accounts, first by identifying more species than Cope, secondly by living several years longer than his rival, and finally by dint of the increasingly evident fact that Lamarckism was wrong: acquired characteristics (still) could not be inherited.

In Darwin's work, evolution was presented as a constantly branching process where a single early species becomes many species through variation and natural selection. Natural selection did not address the creative or birth-factor, but rather explained a mechanism that operated after there is something to affect.[85] Cope spent most of his career seeking an alternative mechanism for evolution that permitted a supernatural creative force at the outset and then linking the fossil structures he was unearthing into a linear progression. He relied heavily on Lamarck's ideas when attacking the randomness evident in Darwin's theories on evolution.[86] He proposed

82 Rudwick, *Bursting the Limits of Time*, quoting Lamarck on p 390.

83 Brian Regal, *Henry Fairfield Osborn: Race, and the Search for the Origins of Man* (Aldershot, United Kingdom: Ashgate, 2002), 52.

84 *Ibid*.

85 Osborn bases his remarks on Darwin. See *On the Origin of Species by Means of Natural Selection: Or, the Preservation of Favoured Races in the Struggle for Life* (London: John Murray, 1859); *The Variation of Animals and Plants under Domestication*, 1868. See also Edward Drinker Cope, *The Primary Factors of Organic Evolution*, Chicago, 1896; *The Origin of the Fittest*, 8 vols. (New York, 1887).

86 Alexander Vucinich, *Darwin in Russian Thought* (Berkeley: University of California, 1988), 157.

a law of acceleration of growth, which Bowler has described as a "philosophy of development completely alien to Darwinism" where all organisms advance through a pre-ordained hierarchy of stages, with some accelerating through the steps, going faster and farther than other species.[87] Cope also suggested a law of growth and effort, where more limbs would appear, become used, and passed on to the next generation. American zoologist Alpheus Hyatt agreed with most of Cope's arguments and became interested in the origin of genera as a separate inquiry from the origin of species, compiled this ideas into his most well-known publication, "The Origin of the Fittest."[88] American Lamarckians like Cope and Hyatt continued to find considerable financial and philosophical support because their theories promised an avenue to ensure inheritance of acquired characteristics by subsequent generations, which fit in well with the progressive rhetoric of the day. Lamarckian thought became evident in the earth sciences, and the earth sciences were pivotal to the exploration of western North America, so Lamarckism and western exploration tended to become entangled in some odd ways. Many of the speakers at the ICAS had personal connections to these earlier expeditions. There is no better example of these trends and tendencies than one of Cope's protégés, the American geologist, paleontologist, and eugenicist Henry Fairfield Osborn.

Osborn was the son of railroad tycoon and spent his formative years at the College of New Jersey (later Princeton university) as a "dandy and college wag" where he fell under the influence of Arnold Guyot, who like Louis Agassiz had fled Europe around the time of the 1848 revolutions.[89] Guyot taught geology as "the study of the physical changes of the earth and the life forms on it, and that God had made the earth incrementally."[90] After graduating in 1877 Osborn and several of his friends decided to join a fossil-hunting expedition in the western territories, which he viewed as a last chance at adventure before joining his father's business.[91] The Princeton Scientific Expedition was funded by the school and the US Army, and Osborn and the rest of the paleontology section were tasked with watching out for attacks from local Aboriginal bands and collecting fossils while the group moved through Colorado, Utah and the Bridge Basin of Wyoming.[92]

---

87 Peter J. Bowler, "Edward Drinker Cope and the Changing Structure of Evolutionary Theory," *Isis* 68, no. 2 (1977): 251-2.

88 *Ibid*., 251.

89 Regal, *Henry Fairfield Osborn*, 36.

90 *Ibid*., 37. Regal compares the relationship between Osborn and Guyot to Darwin being taught by Henslow. Guyot's influence is also mentioned in Gregory, William King. *Biographical Memoir of Henry Fairfield Osborn, 1857-1935* (Washington, DC: National Academy of Sciences, 1938), p 407.

91 *Ibid*., 396 and Regal, 41. Osborn's student days are also described in Ronald Rainger, "Paleontology and Philosophy," 270-2. See also George Gaylord Simpson, *Biographical Memoir of William Berryman Scott, 1858-1947. Biographical Memoirs* (Washington, DC: National Academy of Sciences, 1949), pp. 176-77.

92 Ibid. Regal's remarks on their duties are based on the students' report. See H.F. Osborn, W.B. Scott and F. Speir. *Paleontological Report of the Princeton Scientific Expedition of 1877*, vol. 1 (New York: S.W. Green, 1878).

After the expedition, Osborn spent time studying the new collections and working with with the Princeton's president, the Scottish Presbyterian firebrand James McCosh.[93] McCosh was one of the first to teach evolution in America, although historian Brian Regal does not consider him to be a "pure Darwinian."[94] Before Darwin, McCosh followed the work of English naturalist Richard Owen who argued for understanding biology as a revelation of God. After the publication of the *Origin,* he accepted only a teleological form of transmutation. "If evolution were 'properly' understood," McCosh is reported to have said, "it would be seen as the mechanism of God for creating change in the world and not as antagonistic to revealed religion."[95] McCosh argued for a classical education, and supported the notion of absolute truth and meaning. More to the point, he vociferously opposed any notion of relative knowledge.[96] Osborn and his friend William Berryman Scott became the school's first graduate students, and McCosh was grooming them to become faculty.[97] With that intention, Osborn spent some time New York to advance his knowledge of anatomy and physiology with pathologist William Welch at Bellevue Hospital, and then went to England to finish his education, first studying with Scottish biologist and mountaineer Frances Maitland Balfour and then with Huxley at the London School of Mines.[98] He was basically following in the footsteps of Marsh, who had also attended Guyot's lectures in his youth.

Osborn gained connection and polish in England, particularly through Huxley.[99] Huxley was an engaging speaker in class and encouraged his students to seek out a wide variety of knowledge and experience. On one occasion Huxley surprised the class with a short appearance from his friend Charles Darwin, rendering the young Osborn speechless. He later compared the incident

93 *Ibid*., 38 and 43. McCosh's connection to Osborn is also discussed in George M. Cook, "Neo-Lamarckian Experimentalism in America: Origins and Consequences," *Quarterly Review of Biology* 74, no. 4 (1999): 421. Cook's cites Ronald Rainger, *An Agenda for Antiquity* (Tuscaloosa: University of Alabama Press, 1991), see esp. chapter 2.

94 *Ibid*., 39.

95 As summarized by Regal, *ibid*.

96 *Ibid*, 38.

97 *Ibid*., 43.

98 Huxley also taught Osborn's colleague Scott, and leading Canadian geologist George Mercer Dawson. Scott's perspective is discussed by Rainger in "The Continuation of the Morphological Tradition," *Journal of the History of Biology*, Vol. 14, No. 1 (Spring, 1981), see esp pp. 145-9. More important to the pedagogy of ecology, Huxley chose not Osborn but Ray Lankester as one of his protégés. Lankester was an ardent materialist, an exceptional biologist, and a loyal friend of Karl Marx, and he would later mentor Frederic Clements' nemesis, the British ecologist Arthur Tansley. See discussion in John Bellamy Foster and Brett Clark, "The Sociology of Ecology." *Organization & Environment* 21, no. 3 (2008), 334.

99 James D. Teller, "Huxley's Evil Influence," *The Scientific Monthly* 56, no. 2 (1943), 173.

to a sighting of the Loch Ness monster.[100] Huxley provided Osborn career advice on occasion, for example suggesting that Osborn should make a connection with Othniel Marsh after returning to America, hoping that the two might concentrate on building America's scientific capabilities.[101] Regal claimed that Huxley meant Osborn should bring the "Huxley Method" across the Atlantic.[102] Osborn went on to obtain a PhD in anatomy in Germany, studying under Carl Gegenbaur,[103] eventually returning to America under pressure to finally join the family business. After making a limited effort for a few months, it became apparent how much science meant to him and Osborn Sr. accepted his decision to pursue a career in academia but insisted that his son create a different kind of empire at Princeton.[104]

In the early 1880s Osborn analyzed homologies and phylogenetic relationships in evolution.[105] August Weismann had already published his proof against the law of inheriting acquired characteristics in 1883,[106] but historian George Cook claims that this publication did less to setting Lamarckism to rest and more to attack the prevailing "eclecticism" among evolutionists at the time, paving the way for numerous criticisms of Darwinism. As the search for a unified theory of evolution intensified, theories of morphology were applied in the construction of phylogenies.[107] Osborn decided to focus on the fossil record, and returned to Germany to study palaeontology. Then, eschewing Huxley's suggestion to seek out Marsh, in 1885 he went to work with Edward Drinker Cope.[108] Osborn distrusted Marsh, since Marsh was suspicious of anyone requesting access to his collections and had a reputation for not giving his assistants their due.

Cope, Osborn, and their colleagues saw Darwin's concept of natural selection as troubling not only because of its complexity, but because of what they perceived as the theory's "inherent atheistic and chaotic nature: "natural science might be part of the process, but not the "primary

---

100 Regal, *Henry Fairfield Osborn*, 44. Osborn recounted the experience in his *Impressions of Great Naturalists: Reminiscences of Darwin, Huxley, Balfour, Cope and Others*. New York: Scribner, 1924, p 24.

101 Regal, *Henry Fairfeld Osborn*, 45.

102 *Ibid*. When Regal refers to the Huxley Method he is indicating "the conversion of geology-based palaeontology to biology-based palaeontology." Obsorn did well both in his studies and on the social circuit. Regal reported that Osborn met Oscar Wilde, attended a variety of church services, and flirted with wealthy English women.

103 Cook, "Neo-Lamarckian Experimentalism in America: Origins and Consequences," 421.

104 Regal, *Henry Fairfield Osborn*, 45.

105 *Ibid*., 49.

106 Cook, "Neo-Lamarckian Experimentalism," 418.

107 *Ibid*. See also Regal, *Henry Fairfield Osborn,* 60-3. Regal summarized how the focus on outward form and group histories contributed to a prevalent belief in America that a study of the growth of an individual organism could provide a "history" of how the entire group an individual belonged to had emerged.

108 *Ibid*., 65.

agent."[109] Cope's theories became Osborn's own, including his views on society, race relations, and salvation. In 1889, he argued against the new Darwinism, using (incomplete) paleontological evidence to support the transmission of acquired characteristics.[110] Because of Obsorn's increasingly high profile and his proximity to Cope, he became involved with the heated disputes between Marsh and Cope regarding funding and claims for priority over specific discoveries. Osborn, Marsh and Cope were all independently wealthy by their middle age and each had collecting teams working in the American west and shipping fossils back east. They were all attached to Ivy League universities as well as government departments. Osborn landed a position with the Natural History Museum, and Marsh and Cope both became involved with the Geological Survey. Cope was recruited by Ferdinand Vandeveer Hayden, who was well known for mapping Yellowstone Park, while Marsh's contact was John Wesley Powell, who similarly explored the Grand Canyon. As Cope and Marsh both sought to stake a claim as foremost in their field, American palaeontology devolved into the plot lines of a soap opera as the genuine hatred between the two became public knowledge. Their teams fought over and even sabotaged dig sites, bribed railroad agents and generally worked to undermine one another's reputations. When Cope took a position as Head of the Smithsonian's Bureau of Ethnology in 1881, Marsh took his place as Director at the Survey and saw to it that Cope's funding was cut, just when Cope also lost most of his inheritance to a series of disastrous investments.[111]

Cope and his followers created a Lamarckian alternative that embellished Lamarck's law of acquired characteristics. They drafted a "law" of acceleration and retardation related to whether or not biological parts were used. The first force involved was supposedly the organism's interaction with the environment and the second was the organism's consciousness.[112] Cope argued evolution was a series of progessive, parallel lines that rarely touched one another.[113] For a time, Osborn assisted with this effort by focusing on the evolution fossil teeth out of loyalty to Cope more than dislike of Marsh. Then in 1888, when Osborn was in England at the British Association for the Advancement of Science (BAAS) meeting, he was scheduled to speak after Marsh, who had a large collection of teeth that he presented as being different species rather than a single evolutionary

109 *Ibid*., 63-4.

110 Cook, "Neo-Lamarckian Experimentalism," 421.

111 Regal, *Henry Fairfield Osborn*, 54. The dispute is also discussed thoroughly in Cook, "Neo-Lamarckian Experimentalism," and a number of biographical histories. See, for example, Mark Jaffe's *The Gilded Dinosaur: The Fossil War Between E.D. Cope and O.C. Marsh and the Rise of American Science* (Crown Publishing Group, 2000). See also *Bone War: The Excavation and Celebrity of Andrew Carnegie's Dinosaur* (University of Pittsburgh, 2004), esp. pp 69-83.

112 *Ibid*., 64.

113 *Ibid*.

trend. Marsh's talk ran overtime and overlapped with much of the ancillary information offered in Osborn's presentation, cementing enmity between them.[114] Personal differences exacerbated philosophical disputes in palaeontology, and the atmosphere did not become more conciliatory until after both Cope and Marsh passed away. In addition, at the turn of the century, the rediscovery of Mendel's studies permitted an alternative to all forms of Lamarckism and allowed the anti-Darwin fervor to dissipate.

By 1890, Osborn's work was steeped in Lamarckian thought, although there were always ambiguities. For example, Osborn respected the work of August Weismann although he unwilling to accept Weismann's work as "proof of natural selection."[115] Historian Brian Regal has identified a break with the past that Osborn went through in the 1890s that was probably exacerbated by deaths within his inner circle (his father in 1894, his infant son in 1896, and his mentor Cope in 1897). During this period, Osborn suggested a variation where incremental changes are transferred and added to existing characters in the germ plasm.[116] He called his hybrid theory "Lamarckism plus-not-versus Darwinism," and he set out to manipulate germ plasm theory in hopes that a type of "race plasm theory" could exist. His attempts were unsuccessful, although they placed Osborn squarely in the center of a shift that historians of science Ernst Mayr, Peter J. Bowler, and George Cook have identified where Lamarckian experimentalism was revived and then abandoned once the potential of Mendelian genetics arose. Cook found that the experiments Osborn conducted at Cold Spring Harbour experimental station during this period were substantial contributions to this movement, and the data generated in his programs "provided a significant part of the empirical basis for synthetic Darwinism."[117] Osborn "slipped away" from Lamarckian thought towards natural selection of his own accord, based on his own results.[118]

At the ICAS, Osborn was tasked with clarifying the relationship between palaeontology and biology and identifying the current problems of the field. In the process of distinguishing between the two (or emphasizing the overlap, as was the tendency in this case) he reminded the audience that the appearance of new characteristics remained the crucial point in what his old mentor Cope had called "the origin of fitness." Osborn suggested that naturalists tended to under-emphasize selection as the supreme factor: "certain of the creative factors cannot be seen at all by palaeontologists; others, in my opinion, cannot be seen by zoologists."[119] He had long since

114 *Ibid*., 66.

115 *Ibid*., 67.

116 *Ibid*., 74-6.

117 Cook, "Neo-Lamarckian Experimentalism," 418.

118 Regal, *Henry Fairfield Osborn*, 68.

119 Osborn, "The Present Problems of Palaeontology," 569.

recognized that the infighting in the evolution camp only benefited a small remnant of stalwart Creationists. Cook has identified 1891 as the point when the futility of the disputes were apparent to Osborn, since that is when he wrote to *The Atlantic Monthly* that the "war of opinion" among evolutionists constituted a "fratricidal conflict [and] must afford keen satisfaction to the worthy conservatives who are still nursing their doubts."[120] By 1904, he seemed to be anticipating the Darwinian synthesis.

Historians of science Stephen Jay Gould, Peter J. Bowler, and Adrian Desmond separately concluded that a commitment to philosophical idealism played a strong part in the challenge to Darwinism made by Lamarckian palaeontologists. The dinosaur hunters were seeking a plan and purpose for nature. Historian Ronald Rainger has supported these studies, but also argued that the attack reflected to at least the some degree certain limitations of their training and the data they had amassed.[121] Rainger's commentary suggests that the wider ecology network was unevenly integrated. The mainstream of English and German biology may have eschewed any version of Lamarckian theory, but some pockets and French and American biologists continued to seek a Lamarckian mechanism, despite numerous indications that the quest was futile.

Biology during Oscar Drude and Benjamin Lincoln Robinson's prime was wracked with conflicts that forced a re-examination of the species question in light of the philosophical preferences of the day. In particular, the relationship between progressivism and Lamarckism created a social mandate for researchers to unite a teleological orientation with the precepts of evolution, leading into a number of blind alleys for biological research. The professionalized atmosphere was both liberating and frustrating. For the early ecology network, the turn of the century brought the first opportunities for employment in professional scientific ecology. It also created a host of expectations related to professionalization, including the need to attain credentials from specific institutions, create strategic social alliances, and, whenever possible, re-locate studies into a laboratory environment. The future of ecology, however, was rarely found in a laboratory study. Just as had been the norm for nearly a century, the way forward would be forged through field studies and interdisciplinarianism. Twentieth century ecology would incorporate more concepts from the humanities. Once ecologists became accustomed to considering humans as part of natural world in their case studies, the field eventually created a niche providing research and analysis for political movements seeking to mitigate the effects of human society on the environment. Before achieving this level of legitimacy, scientific ecology would have to struggle for decades to determine how its practitioners could best interact with a public audience.

---

120 Cook, "Neo-Lamarckian Experimentalism," 421. Quoting Henry Fairfield Osborn,"The Present Problem of Heredity." *The Atlantic Monthly* 67 (1891), 353-364.

121 Ronald Rainger, "Palaeontology and Philosophy: A Critique," *Journal of the History of Biology* 18, no. 2 (1985), 269.

CHAPTER SIX

HISTORY AND ECOLOGY

In 1962, an otherwise mild-mannered marine biologist released a blistering critique of the use of pesticides in industrial agriculture. In the often-quoted last paragraph of Rachel Carson's *Silent Spring*, she attacked the mental attitudes evident in the early stage of life science:

> *The "control of nature" is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man.. .. It is our alarming misfortune that so primitive a science has armed itself with the most modern and terrible weapons, and that in turning them against the insects it has also turned them against the earth.*[1]

The nineteenth century did indeed embrace the "nature-conquering" ideal, as biologist Alfred Giard discussed in his speech at the International Congress of Arts and Science (ICAS), and that laboratory-based model held a great deal of sway over a generation of scientists and politicians.[2] Yet the same period magnified a new paradigm in the life sciences, one that focused on understanding the relationship between living populations and their environments, and investigating how species evolve. In fact, the early life sciences developed a wide array of scientific practices that had ethical implications, from vivisection to eugenics to ecology.

Exploration of the natural world in the nineteenth century was typically undertaken for the advancement of nation-states. As has already been discussed, the territories of the Mississippi drainage basin were relatively unknown at the time of the Louisiana Purchase in 1803. President Thomas Jefferson's dream had been to see ordinary people explore, conquer, and settle in the territory. Physical data on the interior of North America collected during surveying expeditions contributed to the new conception of how the physical world functioned, but the main impetus of all government-sponsored expeditions was to identify any potential for commercial exploitation. Above all else, Jefferson had wanted to establish successful agricultural settlements in the western grasslands. A relationship between the federal government and the homesteader was forged and this partnership remained steadfast, if occasionally strained by the vagaries of climate and politics.

The new Westerners tended to be progressive in political disposition. They established societies and self-help clubs, and were amenable to assistance from the government for farm improvement. The provision of land grant universities permitted a new type of self-made

---

1 Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin ebook, 2002), 567.0.

2 Alfred Mathieu Giard, "The Present Tendencies of Morphology and Its Relations to the Other Sciences," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York: University Alliance, 1908).

individual, one that could rise up from rural roots within western universities and go on to establish a career in research and higher education without needing to physically relocate to the eastern seaboard or Europe for extended periods of time. Some of these college-educated specialists found employment at western colleges or with the government—and some continued on as practicing farmers and ranchers, as well. The new professional was embodied in Charles Edwin Bessey, who established the "New Botany" through his seminars at the University of Nebraska. The New Botany was a biology-oriented approach to the understanding the plant world that employed both experimentation and observation, and emphasized physiology and ecological issues. The approach was implemented in classrooms of American land grant universities as they became established, and it soon became the norm in all North American colleges. The New Botany was well-represented at the ICAS. Bessey chaired the session on plant pathology, his close friend John Merle Coulter was a keynote speaker in the biology section, and Bessey's most famous student, Frederic Clements, was serving as secretary in ecology.

Charles Bessey and the Missionaries of Botany

Historian Ronald Tobey examined the career of Bessey, and determined that his efforts "nurtured into life the new science of ecology."[3] Tobey argued that the fundamental concepts of the New Botany originated in Europe but became something distinct in the USA under the leadership of men like Bessey. As Tobey points out, Bessey never studied in Europe but he was not an outsider.[4] After graduating from Michigan Agricultural College he spent a year under the tutelage of botanist Asa Gray, he served as an editor of *The American Naturalist* when it was guided by paleontologist Edwin Drinker Cope, and he became close friends with leading biologist and college administrator John Merle Coulter.[5] Bessey established himself as a professor at Iowa State University and advanced within the university administration until serving as President in 1879, then relocated to the University of Nebraska shortly after assisting with the writing of the Hatch Act in 1887, which provided federal funding for land-grants colleges and agricultural experiment stations. Bessey was not an ivory tower intellectual. He worked closely with the agricultural experiment stations to make scientific botany a practical resource.[6] He agitated, for

3 Ronald Tobey, *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895-1955*. (Berkeley: University of California, 1981), 9.

4 *Ibid*., 10.

5 The alliance between Coulter and Bessey was based on similar philosophical outlook. They popularized the New Botany and encouraged the use of the methods of Julius Sachs in the classroom. See William Trelease, *Biographical Memoir of John Merle Coulter*, 1851-1928, vol. 16 (Washington, DC: National Academy of Sciences, 1929).

6 Tobey, *Saving the Prairies*, 14. See also Richard A. Overfield, "Charles E. Bessey: The Impact of the "New" Botany on American Agriculture, 1880-1910," *Technology and Culture* 16, no. 2 (1975).

example, for a dedicated plant pathologist at the USDA.[7] Bessey was considered one of the top hundred most important contributors to American science in 1910. He encouraged his students to become "missionaries of botany," but he himself was not the foremost botanist in America. Historian Ronald Tobey suggests that position would have been cemented if he had been appointed Asa Gray's successor,[8] but it was Benjamin Lincoln Robinson who held that title. Bessey's main identity was as a botanist, not an ecologist. Therefore, despite Tobey's assertion that Bessey was a founder of the American ecology, it was his student Frederic Clements who served as secretary of the ecology session at ICAS, and who later became associated with a specific school of thought in ecology: "Clementsian" ecology paired idealistic philosophy with a mechanistic explanation for plant succession within communities.[9] Looking at the situation from a broad perspective, it is clear that Bessey operated on the periphery of the global ecology network, but as his career illustrates, a lot could happen on the peripheries.

Early in his career, Bessey argued against including ecological methods in high schools because he believed the approach lacked rigor.[10] He kept abreast of the trends in European botany, however, and went out of his way to disseminate new concepts and methodology when they became available. He created a standard textbook for American students based on German botanist Julius Sach's popular *Lehruch der Botanik*.[11] He also introduced German phytogeographer Oscar Drude's work during his botanical seminars. Quadrats, grids where species were counted, were used in Drude's investigations of the plant geography of Germany, but the method was considered problematic by some because it relied on a qualitative concept of abundance, where differences in plant characteristics within the quadrat were compared rather than counted. This approach was not

7 Mark D. Hersey, "'What We Need Is a Crop Ecologist': Ecology and Agricultural Science in Progressive-Era America," *Agricultural History* 85, no. 3 (2011), 297-321.

8 Tobey, *Saving the Prairies*, 12.

9 Clementsian ecology did not rise to the foreground until after 1905 when he published his text on methodology. See Frederic E. Clements, *Research Methods in Ecology* (Lincoln: University of Nebraska, 1905). Of the numerous analyses available on Clements, the most well known are Tobey's treatment and Worster in *Nature's Economy* (see Chapter 11, esp. p 235-9). For a recent discussion of his network, see Joel B. Hagen, "Clementsian Ecologists: The Internal Dynamics of a Research School," *Osiris* 8 (1993), 178-95.

10 Tobey, *Saving the Prairies*, 37-9.

11 Julius Sachs was the first specialized plant physiologist, and his textbook on plant physiology was published in Germany as *Lehrbuch Der Botanik: Nach Dem Gegenwärtigen Stand Der Wissenschaft* (Leipzig: W. Engelmann, 1868). Bessey's adaptation was *Botany for High Schools and Colleges* (New York: Henry Holt, 1880). The exposure of American students to Sachs' textbook, whether they studied in the United States or in Germany, is an excellent example of cross-Atlantic knowledge transfer in the sciences. At a celebration of Sachs' 100th birthday held at the Missouri Botanical Garden, numerous speakers recalled the deep effect this publication had on them. For further discussion see Charles F. Hottes, "The Contributions to Botany of Julius Von Sachs," *Annals of the Missouri Botanical Garden* 19, no. 1 (1932).

appropriate where vegetation was relatively sparse and uniform, as it was on the prairies.[12] Thus, some of the methodology and much of the philosophy was either altered or abandoned in Bessey's translations. Sachs' German idealism gave way to American pragmatism, and Drude's qualitative assessment of plant species density within a quadrat was replaced in favour of a quantitative analysis designed by two of Bessey's students, Frederic Clements and Roscoe Pound. [13]

Bessey's influence was considerable in the ecology network, in some ways more-so than his well-known student. John Merle Coulter recalled in his obituary note for his friend that Bessey was unfailingly polite and pleasant, and he claimed that in part because of this unflagging positivity "no American botanist left his mark on so many students" as Bessey did, with their loyalty to him remaining intense throughout their careers.[14] Younger botanists were inspired by both Bessey and Coulter, and learned from these senior botanists to use the New Botany "to define a body of knowledge that they controlled to the exclusion of amateurs and other scientists."[15] Historian Keeley discussed how amateur and professional networks became increasingly incompatible or even estranged during the 1880s and 1890s under the rise of New Botany. It is not conclusive that the estrangement was entirely to the benefit of the new professionals because they lost much of the old volunteer collecting networks in the process.

Bessey and Coulter possessed sufficient clout that they were able to convince the National Education Association in 1892 that it would be best to prioritize botany over zoology in high school biology.[16] They were not wholly successful in implementing the New Botany at the high school level, however, since secondary schools found the Nature-Study movement to be more accessible and inexpensive. The shift to scientific botany at the post-secondary level was permanent, and secondary schools and amateurs gravitated to the new Nature-Study movement. Efforts to bridge the gap were only occasionally attempted. Public outreach from western colleges occurred mainly through the personal initiative of professors contributing to Farmer's Institutes and the like, and

12 Tobey, *Saving the Prairies*, 52.

13 Amendments to Julius Sachs were not unusual. Sachs' laboratory in Vienna was a major hub for any botanist interested in the specialty but his authority did not go unchallenged. As historian Adrian Desmond discussed, Darwin corrected details on touch sensitivity on plants given in Sachs' textbook. Sachs in turn criticized Darwin's experiments for being based in a home rather than a laboratory; he and his colleagues were unable to replicate them. Thomas Henry Huxley's semi-professional X Club in turn argued that the German system had become over-professionalized. For further discussion see Desmond, "Redefining the X Axis: 'Professionals,' 'Amateurs' and the Making of Mid-Victorian Biology: A Progress Report," *Journal of the History of Biology* 34, no. 1 (2001). See also Soraya De Chadarevian, "Laboratory Science Versus Country-House Experiments: The Controversy between Julius Sachs and Charles Darwin," *The British Journal for the History of Science* 29, no. 1 (1996).

14 John Merle Coulter, "Charles E. Bessey," *Science* 41, no. 1060 (1915).

15 Elizabeth Keeney, *The Botanizers*, 149.

16 *Ibid*.

also through appearances at events such as expositions. Some of the grasslands group that Bessey had established were at the St. Louis Fair primarily to interact with the public. A narrative on progressive agriculture was created through the pairing of lectures with exhibits. There were a variety of ways for life scientists to be involved at the Exposition: through the lectures at the ICAS; by judging the exhibit and livestock competitions; and by designing and presenting displays. The combined effort provided a glimpse for American agriculturalists of what might be possible with the application of ideas and technology—and in the next decade a number of new fields emerged to satisfy these emerging interests, including but not limited to agricultural economics and ecology.

Bessey provided an essential link between German floristics and American grasslands ecology. Tobey featured Bessey as one of fifty-eight scientists constituting the grasslands school, but argued that Bessey's interests were too diverse to position him as a leader in scientific ecology.[17] Bessey's network was pedagogical. Tobey focused on Clements, clarifying the immediate social and intellectual setting where the younger ecologist's ideas were born. Clements is now associated with the tradition that views the plant community as a super-organism.[18] Tobey discussed Clements' years at the University of Nebraska and the instructional content of Bessey's courses. Clements was also influenced by Spencerian sociology. Tobey then provided a network study for Clements and the grassland biologists by analyzing their publications.[19] The weakness of Tobey's approach was that it emphasized publishing academics in the network and minimized the contributions of amateurs and professionals that focused on applied problems.[20]

---

17 Tobey, *Saving the Prairies*, 238.

18 Gregory Cooper, *The Science of the Struggle for Existence: On the Foundations of Ecology* (Cambridge, UK: Cambridge University Press, 2003), 37.

19 Tobey, *Saving the Prairies*, for full details see the explanation in his Methodological Appendix. Tobey's narrative focuses on the struggle of the grassland ecologists to comprehend and preserve the prairies, and he argues that in the process they "created the science of ecology, considered in a professional sense, in the United States," see 2. He highlights the theory of succession and explains how it spread throughout the English-speaking world.

20 Tobey regarded ecology as a fully developed discipline before 1914. His argument was based on the existence of a ecological community: he cited philosophers of science Michael Polanyi and Thomas Kuhn, who argued that scientific knowledge was "intimately related to the personal commitments and tacit knowledge of the scientists." He also referred a study by sociologist Diana Crane that connected scientific knowledge to the establishment of new fields in a series of steps. First, knowledge was "innovated" by a small group of collaborators, then it was diffused among the scientific community via publication, and finally the audience contacted the originators, often at conferences. The linked collaborative groups eventually constituted a new field. Tobey saw this coalescence occurring with the research of Clements. The ICAS itself can also constitute an example of when receivers contacted originators. See Tobey, *Saving the Prairies,* 111-3. Polanyi's theory is explained in Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy* (Chicago: University of Chicago, 1958). For an updated discussion of Polanyi's thought and the study of scientific community, see Mary Jo Nye, "Historical Sources of Science-as-Social-Practice: Michael Polanyi's Berlin," *Historical Studies in the Physical and Biological Sciences* 37, no. 2 (2007). See also Diana Crane, *Invisible Colleges: Diffusion of Knowledge in Scientific Communities* (Chicago: University of Chicago, 1988).

Looking at the social network of the grasslands ecologists, the ICAS is one of several key sites where the nascent field of scientific ecology coalesced. Another would be the International Phytogeographic Excursion of 1911. Oscar Drude, the inadvertent contributor to the establishment of grasslands ecology through Bessey's translation, was a featured participant in both the exposition and the excursion.[21] If the focus is shifted away from Clements and the innovation he produced in partnership with Pound, and instead looks to how Drude was able to revitalize phytogeography in Germany, it becomes clear that like Bessey, Drude is a major node in the early ecology network.

Oscar Drude and Modern Ecology

Oscar Drude was a major influence on early botanical ecology. Ronald Tobey describes Drude's plant geography as the culmination of a pedagogical tradition of European floristics originating with Alexander von Humboldt, but historian Nils Güttler attributes some of the new methodologies Drude pursued to a unique interaction between popular and scientific culture. He has explored the "mapping impulse" that Drude became involved in during this period as a major contribution that shaped scientific ecology.[22] Drude learned to use a technique called *Totaleindruck*, which permitted the observation of interconnectivity of physical phenomenon on a map at a glance.[23] He was introduced to this technique through personal and professional connections. In his case they were thoroughly woven together: his wife, Lydia, was the daughter of a surveyor and an experienced map-drawer, and his mentor, August Grisebach, connected him with *Perthes Verlag*, a publishing house that specialized in maps.[24] The publishing house contained an extensive archive and library, and featured a factory-like environment with dozens of men and women employed in the production scheme. Grisebach served as their external botanical expert as a supplement to the salary he earned as a lecturer. When he was ready to resign due to his advancing years, he recommended that Drude take on the position. Drude was twenty-four years old and completely untrained in geography when he first began to work with *Perthes*. Fifty years later he was considered one of the world foremost experts on plant cartography.[25]

---

21 Several historians have discussed the impact of Drude's methodology. See Nils Robert Güttler, "Scaling the Period Eye: Oscar Drude and the Cartographical Practice of Plant Geography, 1870s–1910s," *Science in Context* 24, no. 01 (2011), 32-3; Robert Macintosh, *The Background of Ecology: Concept and Theory* (Cambridge, UK: Cambridge University Press, 1985), 28; Ronald C. Tobey, *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895-1955* (Berkeley: University of California, 1981), 51-69; and Donald Worster, *Nature's Economy: A History of Ecological Ideas* (Cambridge, UK: Cambridge University Press, 1985 edition, first published 1977), 198-206.

22 Güttler, "Scaling the Period Eye," 4.

23 *Ibid*., 3.

24 *Ibid*., 14.

25 *Ibid*.

Drude and the team at *Perthes* synthesized flora and vegetational lines in such a way that the map could function as a discursive object, rather than just a summary of results that was subordinate to the text. By layering information, they were able to examine problems involving plant distribution, phenology, and crops that may not have been identified if the analyses were separated.[26] The mapping of the relationships between organisms and their environment constituted a clear example of ecological thinking. Drude's success in landing a position at the *Königlich-Sächsisches Polytechnikum* was directly related to the practical skills that he gained at *Perthes*, and the new professorship involved work with the agricultural research station, the botanical garden, and governmental partnerships. Both Drude and Bessey demonstrate the close links between early ecology and agriculture.

Drude and Bessey were both working in what Drude had identified as the fourth phase of ecology, and they were active in what he called the fifth or "modern" phase. Drude had indicated in his speech that "modern" ecology was inaugurated by the publication of Conrad MacMillan's survey of the *Lake of the Woods* (1897) and Eugene Warming's *Lehrbuch der okologischen Pflanzengeographie* (1896*)*.[27] Warming was an obvious inclusion, one of a handful of prominent, physiologically-oriented German botanists publishing near the end of the nineteenth century. Historian Gregory Cooper, while noting that Frederic Clements saw Drude as his intellectual ancestor, reminds his readers that fellow American botanist Henry Cowles saw his work following from Warming. Cowles had written in 1898:

> *It may be too early to predict whether the direction of future work in plant geography will be given by Warming or by Drude; and so whether we shall speak of ecology or phytogeography, or of life forms or of vegetational forms, or plant societies or formations is yet to be decided.*[28]

English ecologist Arthur Tansley also acknowledged Warming as pivotal to his schooling, and lamented the fact the *Lehrbuch* was not translated into English until 1909.[29] Drude's reference to MacMillan was more unusual, but he justified its inclusion because MacMillan had discussed the reasons for the changing appearance of particular formations: it was the first time in America

26 *Ibid*., 17.

27 Oscar Drude, "The Position of Ecology in Modern Science," *International Congress of Arts and Science* 9. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 182.

28 Cooper, *The Science of the Struggle for Existence*, 37.

29 Arthur Tansley, "The Early History of Modern Plant Ecology in Britain," *The Journal of Ecology* 35, no. 1/2 (1947), 130. How much that lack of translation was a real impediment is doubtful, since Clements, Cowles and Tansley all were able to read it in the German translation.

an attempt of this sort had been made.[30] According to Drude, both these works acknowledged the special province of ecology but emphasized the role of biology over the geography within the orientation of the new field.[31] Drude interpreted this preference as an indication that a shift was occurring away from fieldwork towards laboratory methods, but he was pleased that the drift was corrected by botanist Andreas Franz William Schimper, who "fulfilled Grisebach's unattainable dream" by forging a close bond between ecology and phylogeny.[32] "Evolutionary thought," Drude concluded, "which is the keynote of modern natural science, may proceed along two lines" where the first would look at the variation of species in regard to their spatial requirements, and the second is the variation of an association under the influence of successive generations, each of which has undergone modifications.[33] He saw much important work in progress: Jules Bonnier and his attempts to prove the direct effect of change of climate upon the variability of specific forms; Léon Géneau de Lamarlière and his use of the *physiologie specifique* to express the idea of the degree of adaptation accomplished; and Austrian Richard Wettstein and his reconsideration of the taxonomic system based on evolutionary history.[34] Drude recognized ecological thinking in all these men, and he too continued to publish on phytogeography and contribute to the growth of professional organizations in botany and ecology for the remainder of his lengthy career.[35]

The Robinson Brothers and Scientific History

Six months before the ICAS was held, botanist John Merle Coulter provided a celebratory lecture for five visiting German dignitaries that were being awarded honorary degrees at the University of Chicago. Coulter claimed that German universities provided their American counterparts with exemplary norms by making research the primary focus of academic institutions, permitting faculty intellectual independence, and allowing scientific research for its own sake.[36]

30 Drude, "The Position of Ecology," 188. For a summary of the intellectual relationship between Grisebach and Schimper, see also Eugene Cittadino, *Nature as the Laboratory: Darwinian Plant Ecology in the German Empire, 1880-1900* (Cambridge, United Kingdom: Cambridge University Press, 1990), 114.

31 Drude, "The Position of Ecology," 182.

32 *Ibid*., 183.

33 *Ibid*.

34 *Ibid*., 184.

35 Drude's position in Dresden would be passed on twenty years later to the German-Swiss botanist Friedrich Tobler (1879–1957), who ably carried on his work until an air raid on February 13, 1945, destroyed the conservatories and the official residence on the botanical gardens, as well as most of its extensive collections Drude had amassed. Tobler, who had fought to remain in the position despite considerable disapproval from Hitler's authorities due to his marriage to Jewish biologist Gertrud Tobler-Wolff (1977-1948), relocated to Switzerland after the destruction of the grounds.

36 John W. Boyer, "*We Are All Islanders to Begin With:" The University of Chicago and the World in the Late Nineteenth and Twentieth Centuries* (Chicago: College of the University of Chicago, 2008), 11.

Coulter's preference was for scientific research conducted in a professionalized environment. In September at St. Louis, when his assignment was to clarify the shift in mental attitude regarding morphology that occurred during the nineteenth century, he remarked that:

> *It is almost impossible for one age to conceive of the mental condition that was satisfied with the explanations of a previous age. In this case it must be remembered that the earlier botanists were either ecclesiastically trained or not trained at all, and to them it was entirely satisfying to explain all metamorphoses upon teleological grounds.*[37]

Coulter was by no means a historian, or even much of a diplomat. His remarks were dismissive of previous generations of scientists and derogatory towards amateur botanists. He saw botany in the earliest phase, when the mature specimen was the primary subject of study, as indulging in "the reading of complexity into simplicity" and happily found it "safe to say" it was in irreversible decline.[38] He described the phase that followed as one where botanists focused on the structure of the developing organ and then condensed the process into "life-histories" (his quotation marks). He noted that by "shifting its center of gravity from the mature organ to the nascent organ, morphology departed very far from special taxonomy" and laid the foundation for general taxonomy.[39] Those early evolutionary explanations were the "spirit of modern morphology" but he expressed disappointment, even disapproval, that it "has not yet dominated instruction" in all of America's schools.[40]

Biology had become historical over the course of the nineteenth century and during the same period, history had become more scientific. Historians and biologists still have similar philosophical approaches, albeit different perspectives. It is, after all, a major task of historians to understand the mental condition of the previous age. Harvard ecologist Benjamin Lincoln Robinson would have been acutely aware of this fact, being the brother of Columbia University historian James Harvey Robinson, who was also participating in the ICAS that week. Robinson the historian was serving as the young, American scholar speaking on methodology after a keynote speech by Princeton University President (and future American President) Woodrow Wilson on "The Variety and Unity of History."[41] In his speech, James Robinson made points that mirrored concerns of scientists at the time. He encouraged historians to embrace scientific study and move

37 John Merle Coulter, "Development of Morphological Conceptions," *International Congress of Arts and Science* 9 Ed. Howard Jason Rogers. London and New York: University Alliance, 1908), 31.

38 *Ibid.*

39 *Ibid*., 32.

40 *Ibid*.

41 Woodrow Wilson, "The Variety and Unity of History," *International Congress of Arts and Science* 3.(London and New York, University Alliance, 1908), 3.

away from religious apologetics, lamented the need of historical publications to appeal to the public, and admonished historians not to allow literary ideals in their writing.[42]

Speakers at the ICAS were eager to demonstrate the reliability of scientific methods everywhere, including in the humanities. Like Coulter, Benjamin Robinson attributed the improved methodology in American academia to German influence. He believed that overspecialization in his field, however, was rampant and showed disregard for unity and continuity. He devoted the majority of his lecture to expose the recklessness of over-periodization in history: "Periods in history may perhaps be best viewed as mere divisions into chapters, indications on the part of the writer of those stages in the narrative where the reader may most safely and conveniently put down his book for a moment."[43] It is hard to ignore the emphasis on continuity in the comments of both Robinson brothers when compared against Coulter's and even Oscar Drude's respective summaries of biology. Drude had used the presence of five distinct periods as an indication that a great volume of ecological thinking was evident in the nineteenth century, but the tendency towards periodization, as James Robinson pointed out, could lend itself to becoming dismissive of former contributors. In his speech on ecology, Benjamin Robinson did not criticize or sub-divide the past, and instead highlighted a single point where laboratory science enabled improvements in field studies. Interdisciplinary work and the primacy of field studies were most important to the development of scientific ecology, in his mind.

James Robinson similarly argued for incorporating scientific methods into history and cooperating with cognate fields including politics, political economy, anthropology, sociology, and psychology. He hoped that cognate fields could free history from "the trammels" of literature and supply what he saw as rigor for the study of human society. Benjamin Robinson, for his part, saw potential for scientific ecology to support practical science that focused on service to humanity. Neither brother seemed to imagine that ecology itself would develop to include the study of the human relationship with nature. Furthermore, neither the Robinson brothers in 1904 foresaw a time when the two kinds of sources, the textual data and the natural history sources, would be used to reinforce one another. James Robinson and his colleague in the "American History" section, Frederick Jackson Turner, did encourage young historians to look to new sources such as newspapers, correspondence, and business records. Of the two, only Turner explicitly implicated the role of the environment on the development of human society. He included biology as one of the cognate sciences that could contribute to scientific history.[44]

---

42 James Harvey Robinson, "The Conception and Methods of History," *International Congress of Arts and Science* 3.(London and New York, University Alliance, 1908), 40-2.

43 *Ibid*., 44.

44 Frederick Jackson Turner, "Problems in American History" *International Congress of Arts and Science* 3.(London and New York, University Alliance, 1908), 191.

Turner's chief interest was in analyzing the results of Thomas Jefferson's settlement project, which involved a major shift in land use. The development of the Louisiana Purchase lands required decades to implement, and relied on the talents of thousands of scientists and tradespeople. Professional, systematic scientific inquiry was an essential part of comprehending and settling the West. Field science proved pivotal in providing a "shape" for the West. Nor was it a wholly American enterprise. Much of the upper Mississippi Basin was dominated by the Great Plains, rising from the 100th meridian in the east to the craggy Rocky Mountains in the west, and this biome also included settlements in the British North-West Territories. International scientific cooperation, therefore, is as much a part of Western history as is fur-trading, cattle drives, and gold rushes. The existing, overarching historical narrative claimed that white Americans had entered unfamiliar territory and adapted to its requirements, while at the same time the environment reshaped their society. In other words, the study of the relationships between organisms and their environment was already part of historical practice in the West.

Frederick Jackson Turner and the Natural History of the American People

Frederick Jackson Turner made his career with a short speech at the Columbian exposition in 1893 entitled "The Significance of the Frontier in American History."[45] Today he is remembered for this first major thesis, the most influential piece of writing on American history.[46] An obituary provided by the American Geographical Society claimed that "all who would interpret the larger movement of American life have been obliged to take Turner's ideas into account."[47] Environmental historian William Cronon has even asked if there is anything left to say about Frederick Jackson Turner, and suggested that even summarizing the essence of the thesis, as will be done in this section, is to engage in ritual.[48] Yet in a discussion about ecology, western history, and the ICAS, Turner must be included, since he was a major speaker. Throughout his career, Turner focused on teaching at the University of Wisconsin, producing a generation of doggedly loyal historical social

45 Frederick Jackson Turner. "The Significance of the Frontier in American History," in *American Historical Association Annual Meeting* (World Columbian Exposition, Chicago, Illinois: Bobbs-Merrill Reprint Series in History, 1893).

46 William Cronon, "Revisiting the Vanishing Frontier: The Legacy of Frederick Jackson Turner," *The Western Historical Quarterly* 18, no. 2 (1987), 167. Cronon explains the contradiction in that thesis is that the national character was found in the frontier, but the whole point of the frontier was for it to vanish under the onslaught of civilization.

47 Editorial, "Obituary: Frederick Jackson Turner," *Geographical Review* 22, no. 3 (1932), 499..

48 Cronon, "Revisiting the Vanishing Frontier," 157. Cronon goes on to summarize the arguments of Turner's critics, who often complain that Turner was more of a poet than a logician, that he under-emphasized or even misunderstood the cultural complexity of frontier regions, and that his thesis cannot resonate with ethnic minorities.

scientists for the mid-West.[49] In 1904 he had just begun to lecture at Harvard as well. He practiced the new scientific history that analyzed rather than narrated.[50] He used his personal experience growing up in the West as a reservoir for his ideas and the state library and archives as his major resource.[51] He habitually found historical evidence not only in government documents, maps and anthropological artifacts, but also in fiction, poetry, personal journals, speeches, and newspapers.[52] While he downplayed narrative as an appropriate mode for historical writing, he accepted literature as historical documents and defined history as "the biography of society."[53] During his career Turner would draw on literature, rhetoric, sociology, and any other field he came across, foraging for ideas that offered insight as he studied the past. One of his favorite hunting grounds was biology, filling file cabinets full of study notes but rarely actually publishing in the discipline.[54]

Turner had planned a number of published works to follow up his ideas on the development of the American West. The initial book was to be a college level history, but inquiries on his progress from his publishers were stonewalled for years. "The subject is growing as a whole," historian Ray Billington quotes Turner as saying, "and it is just now in so formative a condition in my mind that I find it impossible to crystallize any particular portion."[55] By 1901, he had also committed to: a grammar school textbook for Ginn and Company; college and high school texts for Henry Holt and Company; volumes on "The Old West" and the Lewis and Clark expedition for the MacMillan Company; a book on western state-making for A.C. McClurg and Company;

---

49 Turner wanted to write, and planned a number of major textbooks beginning shortly after his successful appearance in Chicago. His poor publication record did leave him vulnerable to attack by his contemporaries when he provided book reviews, which were often harsh even when they involved friends. See discussion in Ray Allen Billington, "Why Some Historians Rarely Write History: A Case Study of Frederick Jackson Turner," *The Mississippi Valley Historical Review* 50, no. 1 (1963), 3-27; Martin Ridge, "A More Jealous Mistress: Frederick Jackson Turner as Book Reviewer," *Pacific Historical Review* 55, no. 1 (1986), 49-63. Ridge quotes one author chiding Turner that "if we differ at all it is because you take the standpoint of a teacher, and I of a writer of history," see p 52.

50 Merrill Lewis, "Language, Literature, Rhetoric, and the Shaping of the Historical Imagination of Frederick Jackson Turner," *Pacific Historical Review* 45, no. 3 (1976), 405.

51 William M. Brewer, "The Historiography of Frederick Jackson Turner," *The Journal of Negro History* 44, no. 3 (1959), 247-8.

52 Lewis, "Shaping of the Historical Imagination of Frederick Jackson Turner," 416.

53 *Ibid*., 417.

54 Cronon, "Revisiting the Vanishing Frontier," 162. He is known today as one of the most important western historians, although he never successfully produced a large scale monograph. Even with that glaring gap in his career, Turner's theories about democracy and the national character had firmly planted itself as a viable history, albeit mythic in character, within the mind of the general public. It also served as a catalyst. Those that attended his lectures were encouraged to carry on and fill in the blank pages he never wrote. It is questionable whether any major publication he provided could have had a larger impact than Turner himself provided.

55 Billington, "Why Some Historians Rarely Write History," 4-5.

and works on "The Disappearance of the Frontier," George Rogers Clark, and the frontier as a whole for Houghton Mifflin Company. Billington sadly recounts that "not one of these books was destined to see the light of day."[56] As the patience of his publishers dwindled, Turner accepted another commitment, this time to speak at the St. Louis World's Fair.

Turner was always a personable and animated speaker in the classroom, and at huge public events those skills shone. His specialization also lent itself well to the forum. In the United States, and only there, universal expositions were explicitly linked to historical events. At the ICAS, where every speaker was asked to provide a historical summary of their field going back to the Louisiana Purchase as the starting point, it was a particularly suitable assignment for the American historian to undertake. His commentary at the ICAS caught the defining spirit of the event. After teasing his international audience that Americans were a people generally more interested in making rather than preserving history, he delved into his long-standing argument that the primary importance of studying American history was to understand the process of social development. He invoked Italian economist Achille Loria's view that the development of colonial societies was comparable to the geologist's inspection of the upheavals of the earth's crust.[57] He also argued that "the factor of time in American history is insignificant when compared with the factors of space and social evolution."[58] His lecture dithered and deliberated over the relative importance of social evolution, dominance, the achievement of civilization, and above all, on the changing use of western land and resources.[59] Essentially, he was suggesting that the North American West constituted an example of human society in an earlier stage of evolution. He also inferred that since all societies developed through the same stages—a description that resembled Lyell's uniformitarianism and even Haeckel's orthogenesis—it was possible to learn more about European ancient cultures by studying what had occurred recently in western North America. He emphasized that the civilizing process was well underway even in the Canadian prairies:

> *where we may pass, by railroad, from the youthful but highly organized manufacturing cities … through regions of increasingly scanty and primitive agricultural occupation, out to the waste of foothills, where the trail of the bison dots the hillside, reaching to the far horizon line and showing the road which civilization will rapidly follow.*[60]

56 *Ibid*., 9.

57 Turner himself had studied geology under Thomas Chrowder Chamberlin, who was speaking in the earth sciences section that week.

58 Frederick Jackson Turner, "Problems in American History," 185.

59 *Ibid*., 184.

60 *Ibid*., 185.

This civilizing process had been at the forefront of Turner's thoughts and his work since 1893, and he noted that "[it] is doubtful whether anywhere more profitable work could be done than in the interpretation of the formation of society in this vast domain of the prairies."[61] According to Turner, American history had repeated the processes of development seen in Europe, but there were also many examples where the problems of American history differed from those of "Old World" history: certainly, sectionalism had been inadequately addressed.[62] In his speech, Turner argued that understanding human social development would require the combined effort of allied sciences, in order to produce results comparable to the spectacular successes achieved in the natural sciences. He encouraged historians to perform cooperative work, appropriating data and methods from literature, art, politics, economics, sociology, psychology, biology, and physiography, for they would all be required to fully understand the evolution of the American people.

It was not surprising that, like Drude and the Robinson brothers, Turner advocated for an interdisciplinary approach. Historian William R. Jacobs has commented that Turner "never regarded his role as historian as a straitjacket" and increasingly embraced a scientific, problem-centred approach in his later years,[63] but cautions that the frontier thesis and the sectional thesis should be understood as formulas that he applied to new puzzles as he progressed with his research (and not as end products).[64] Other researchers have suggested that there are limits to how "scientific" Turner's approach was in actuality. American Studies professor Henry Nash Smith claimed that Turner's use of scientific language was not literal and merely indicated a metaphor, especially his use of terms such as "germs," "growth," "rebirth," and "nature."[65] Literature professor Merrill Lewis decided that Turner's language is not metaphorical but is often rather "expressive."[66] Lewis implied that Turner had become responsive to his audience, and was reflecting the assumptions and prejudices of the day: his evident romantic sensibility satisfied a psychological need in his listeners, but it often indulged in the language of power (the winner writes the history).

---

61 *Ibid*., 193.

62 What he referred to as sectionalism would be described as regionalism today. For further discussion see Cronon, "Revisiting the Vanishing Frontier," 168. Cronon has criticized this second "sectional thesis" Turner offered as lacking overarching structure, a "narrative" that might link the themes into an "organic unity." While Cronon finds the later sectional thesis somewhat clumsy, he thinks it may be more useful in than the frontier thesis for historians seeking interregional connections.

63 Wilbur R. Jacobs, "The Many-Sided Frederick Jackson Turner," *The Western Historical Quarterly* 1, no. 4 (1970).

64 *Ibid*., 362.

65 Lewis, "Shaping of the Historical Imagination of Frederick Jackson Turner," 401.

66 *Ibid*.

These tendencies are confirmed in his speech at the ICAS. Turner provided a compendium of ideas for studies that would investigate "the forces by which the composite nationality of the United States has been created," including studies of relations between the various "stocks" of colonists along with "our" relations with other races in America. He suggested studying "the evolution of the organs of party action" and claimed that his plan for history amounted to "a natural history of the American spirit."[67] Turner noted that American historical sources were recent, abundant, and scattered when compared with European history. Accumulating the sources was so demanding that historians tended to tell American history based on the available domestic records without also consulting the archives of England, France or Spain. Turner argued that "missionaries of history" needed to explore the south and the west for sources, "listing and copying or bringing into secure and accessible libraries the materials" they find as they moved along.[68] This mandate can be considered similar to how Charles Bessey encouraged his students to be missionaries of botany.

Turner was not an ecologist. Nor was he a typical historian. Merrill Lewis placed Turner in a disputed territory between history, literature, and rhetoric, a location that reveals a mythic or historical imagination and, supposedly, contributed to his failure as a historian.[69] While similar detractors maintain that Turner's vision of the American West as a great egalitarian land of opportunity was long ago (and rightly) dismissed, William Cronon positions Turner's career as a starting pistol for western history. As Cronon admits, Turner's essays often sound like orator's speeches and tend towards predicting the future as much as analyzing the past. Turner's preference for oratory over publication created a situation where his legacy was largely pedagogical, like Charles Edwin Bessey's influence on botany. Turner's legacy was embodied in the output of his students. Jacobs describes an army of "Turner-trained men" teaching in the 1920s that included archivists, economists, politicians, and historians.[70] The latter produced much of what Turner was not able to commit to paper.

Cronon asserts that Turner was a historian who was "not at all averse to playing prophet." Historian William M. Brewer goes even further, describing the career of western-born Turner as

67 Turner, "Problems in American History," 184.

68 *Ibid*.

69 Lewis, "Shaping of the Historical Imagination of Frederick Jackson Turner," 404.

70 Jacobs, "The Many-Sided Frederick Jackson Turner," 366.

contradicting the biblical story of the prophet who cannot find respect in his own community.[71] Turner possessed an urge to study history in a manner "not unlike the ministry." Historian Donald Worster maintains that long after his death, Turner still "presides over western history like a Holy Ghost."[72] Perhaps that devotion to the West accounts for the ongoing, posthumous affection for Turner within western history circles. Worster, another historian given to preaching his message, is also a powerful figure in the history of the West and in the history of ecology. It was for this dedication that Turner was celebrated, even after he defected to Harvard in 1910. When colleagues A.C. Krey and E.E. Robinson visited Turner while he packed his office, they found that he had tears in his eyes, and Krey was unconvinced Turner was ever as happy in Massachusetts as he was in Wisconsin.[73]

There is an undefined zone in the midst of Western history, the history of science, and the relationship between history and science. The history of ecology includes, but is not limited to, historians that preached their message, religious adherents that embraced Darwin, Darwinists that drifted into eugenics and race theory, biologists that read geology, and earth scientists that allied themselves with natural historians. At the ICAS, Henry Fairfield Osborn suggested that the scientist must also be an historian; the job requires dealing with lineage, ancestors, problem of kinship and relationship, and the need to distinguish the true from the apparent relationship.[74] By the 1920s, grassland ecologists were influenced by Turner, while Turner himself was investigating glaciation.[75] Moreover, the launch of ecology required those who wrote, those who taught, those who orated, and those who simply thought big thoughts and communicated with one another. Together, they constituted one big network of ecological thought.

---

71 Brewer, "The Historiography of Frederick Jackson Turner," pages 240 and 45, respectively. This reputation for his towering stature endures despite the rumor, recounted by a former student, that young Dr. Turner returned to the University of Wisconsin with a fresh PhD from John Hopkins and was promptly dunked into Lake Mendota by sophomores who mistook him for a freshman. See A. C. Krey, "My Reminiscences of Frederick Jackson Turner," *Arizona and the West* 3, no. 4 (1961), 377-81.

72 Worster is quoted in Frederick Jackson Turner and John Mack Faragher, *Re-Reading Frederick Jackson Turner: The Significance of the Frontier in American History*, and Other Essays (New York: H. Holt, 1994). A century after the Fair, Faragher collected Turner's ten most significant essays. Frederick Jackson Turner's thesis on the frontier creating American society was directly reflected in the grassland ecologists' take on the new scientific field. The grassland scientists believed at the outset of their investigations in the 1890s that vegetational change was inevitably progressive and would override human intervention in the environment. They came to believe, during the later crises of the Dust Bowl, that vegetational change was not necessarily self-repairing.

73 Krey, "My Reminiscences of Frederick Jackson Turner," 381.

74 This characterization was provided by Henry Fairfield Osborn during his presentation. See Osborne, "The Present Problems of Palaeontology," *International Congress of Arts and Science* 8. Ed. Howard Jason Rogers (London and New York, University Alliance, 1908), 574.

75 Jacobs, "The Many-Sided Frederick Jackson Turner," 369.

A difficulty arises when trying to place Turner within the network of early ecology. The Clementsian ecology node had not yet risen to prominence and he is not easily identified with the grassland ecologists. His major thesis was released during Drude's fourth period, but phytogeography and American history were separate spheres at the time. Some overlap existed, however. Turner drew on Lamarckian ideas while constructing his frontier thesis and, like Drude, he was familiar with the work of German geographer Friedrich Ratzel.[76] Turner was a historian who was interested in science and plundered evolutionary biology for terminology and metaphors, but was not directly connected to the scientific network of life science in 1904. He was tacitly attached to Harvard, but not part of Hugo Münsterberg or Benjamin Robinson's circle. At the time of the Fair, Turner was more closely allied with conservationists. He was affected by the writings of George Perkins Marsh more so than Friedrich Ratzel, and he was socially and professionally connected to a number of politicians, not least including fellow speaker Woodrow Wilson, who was credited with providing Turner with a definition for the limits of the frontier. In the spring of 1904, August Charles Krey, who was Turner's student at the time, recalled that University of Wisconsin President Charles R. Van Hise was under fire from the forestry sector for advancing the idea that natural resources needed to be managed and conserved. It became general knowledge that Van Hise was being advised by Turner, and both were targeted by "ultra-conservative antagonism."[77]

Cronon suggested historians should turn away from the "white northern European males who have fascinated them for so long" and explore other aspects of social history, however the history of ecology requires further study of the white northern European males who professionalized history and biology, and established the subfields of ecology, ethnology, and psychology.[78] Each new discipline incorporated contemporary ideas of society and evolution. Cronon claimed much of today's environmental history in the United States is written as Western history, and credited this tendency to Turner, referring to his notion of the frontier and his use of vocabulary concerning abundance and scarcity in nature.[79] The question remains whether his was the best approach for the subject matter. German-American ethnologist Franz Boas, for example, cautioned against indiscriminate application of biological concepts to human society is his ICAS lecture.

76 Sharon Kingsland, *The Evolution of American Ecology, 1890-2000* (Baltimore: Johns Hopkins University Press, 2005), 132-33.

77 Krey, "My Reminiscences of Frederick Jackson Turner," 378.

78 Cronon, "Revisiting the Vanishing Frontier," 171.

79 *Ibid*., 173.

Figure 6.1. Frederick Jackson Turner and the Robinsons within the early ecology network. For complete names, see the appendices.

Franz Boas and Premature Theories of Evolution

Franz Boas was pleased to be included in the ICAS, although he was having a difficult year. He had long been struggling to find a permanent position in anthropology in the United States, working temporary contracts and publishing widely. His most recent stint at the Museum of Natural History in New York had once again ended in mutual bitter estrangement between himself and his employer. As was the trend in Boas' career, there were problems with the title, authority, and salary he was offered. Above all, he demanded financial support and independence to amass and analyze anthropological collections, something that cost-conscious administrators always promised Boas upon offer of employment, but then failed to deliver to his satisfaction.

In his most recent placement, his employer Morris Jesup had liberally expanded upon one of Boas' suggestions and sponsored the most ambitious American fieldwork initiative that had been attempted to date. The research team sought the evolutionary connection between northwest America and northeast Asia by thoroughly studying and collecting on both geographical sides, and the researchers employed were steeped in ecological thinking. The trip had been a success, so Boas was deeply disappointed when appropriate budgetary allocations to study the collections, not least involving a promotion in salary and title for himself, failed to materialize even several years after the fact. In the midst of extricating himself from the museum, he was asked to give a lecture on the history of ethnology at St. Louis. According to his biographer, he hastily wrote the piece on the journey there.[80] His wife and children followed, and they stayed on for nearly a week touring the exhibits. He then went on with his life, leaving what is considered to be the early phase of his career behind, and becoming one of the foremost professors of ethnology in the country.

Boas was a brilliant and difficult personality, trained in physiology and geography but a convert to the historical comparative method; most importantly, he was a pioneer in applying relativism to an academic field. He was a Jewish scientist trained in the German gymnasium, and having emigrated to America he had no intention of returning to Europe. Unfortunately, his specialty, anthropology, was still in infancy in North America. Burdened with a constantly growing family to support and limited prospects, he continued to forge his way forward in the academic circles of North America. He had already conducted fieldwork in the Arctic and on the northwestern coast of North America, edited the forward-thinking magazine *Science*, lectured as a Professor at Clark University and mentored two new graduate students. He had also proposed an entirely new methodology for his field, led several of his field's professional organizations, created exhibits for the 1893 Exposition in Chicago, and attached himself to two of leading museums in the country, the Smithsonian and the Museum of Natural History in New York.

Boas had gained the respect of a number of major intellectuals of the era, with such luminaries as Canadian geologist George Mercer Dawson and American explorer John Wesley Powell overseeing and encouraging his work on occasion. Never one to let his career get in the way of the blunt truth, he typically criticized his contemporaries, often debating academic topics in public forums and journals, circulating furious letters when embroiled in contract negotiations, and even going so far as to examine and then publicly fault the Smithsonian's northwestern exhibit practices. Instead of reconciling himself to the present, Boas tended to idolize the naturalist-explorers of the past. His first studies were in biology. As a child, this doctor-in-training had kept a bust of Alexander von Humboldt next to his bed, and that piece was one of the few possessions he transported when he permanently relocated to America.

---

80 Douglas Cole, *Franz Boas: The Early Years, 1858-1906* (Vancouver: Douglas & McIntyre, 1999), 242-3.

Boas was among both friends and enemies at St. Louis. He was a confidante of anthropology exhibits director William McGee, although he had a low opinion of McGee's capabilities. McGee, by contrast, was unwavering in his support of Boas. It is interesting that Boas, widely regarded as McGee's intellectual superior, was never to learn from McGee's ability to excel at politicking. McGee's ethnological exhibits were considered a highlight of the Fair in 1904, while Boas' own exhibits at the Chicago in 1893, which also included live human specimens, were isolated at the end of the fairway away from public view. It appears that Boas' high self-regard often obscured the reality of the political games that were required in order to succeed in academic circles in America. In his excitement over promoting his new methodology, he often antagonized both publicity-hungry administrators and those "hard" scientists who preferred the certainties of laboratory work.

While committed to the idea of evolution and trained in the sciences, he consistently eschewed the study of genetics and "improvement" programs (i.e. eugenics) throughout his career. Representatives of both of the latter fields were out in force at St. Louis, in particular one of the future leaders of the American eugenics movements, Charles Benedict Davenport. Davenport used his speech as a platform to promote the potential applications of the survival of the fittest.[81] In contrast, in his speech Boas questioned any interpretation of humanity that organized cultures into single line of progress representing the attainment of civilization. He explicitly criticized the fact that these interpretations were still in use by his contemporaries. He expressed these thoughts despite the fact he was speaking directly after McGee, who was the driving force behind the human zoos in the Pike and a colleague that was so thoroughly endorsed by the organizers that he had been scheduled to speak *before* Boas (whereas most of the Americans at the ICAS spoke after their European counterpart). In this context, Boas' hastily compiled remarks cautioning against rash conclusions, and his eloquent support for a more sensitive and humane approach to studying Aboriginal cultures, is all the more remarkable. Boas argued in no uncertain terms that all sciences that "took up the historical standpoint for the first time" soon found themselves "equally guilty of premature theories of evolution based on observed homologies and supposed similarities."[82] Franz Boas is the only example at the ICAS of a speaker who demonstrated both an ecological and ethical perspective in a self-conscious manner.

Ecological thinkers like Boas were highly likely to be familiar with German culture and, in particular, with the work of German biology. It is clear that before the outbreak of World War I, the American and German scientific communities were thoroughly integrated and the development of scientific ecology reflects these long-standing connections. There are also a significant number of early ecologists that were well-acquainted with Western North America. Neither competency was

81 On this occasion, he focused most of those applications on chickens.

82 Franz Boas, "The History of Anthropology," *International Congress of Arts and Science* 10.(London and New York, University Alliance, 1908), 471.

unusual for a nineteenth century academic, since the American educational community was rapidly expanding westward during this period. At least 188 of the participants in the ICAS lived, studied and / or worked in Western North America (38%). The trend, however, appears to be especially pronounced for scientists researching evolutionary biology and scientific ecology. In biology, over a dozen of the speakers had lived, studied and / or worked in western North America. Figure 6.2 details which participants at the ICAS were familiar with Germany and / or the West.[83]

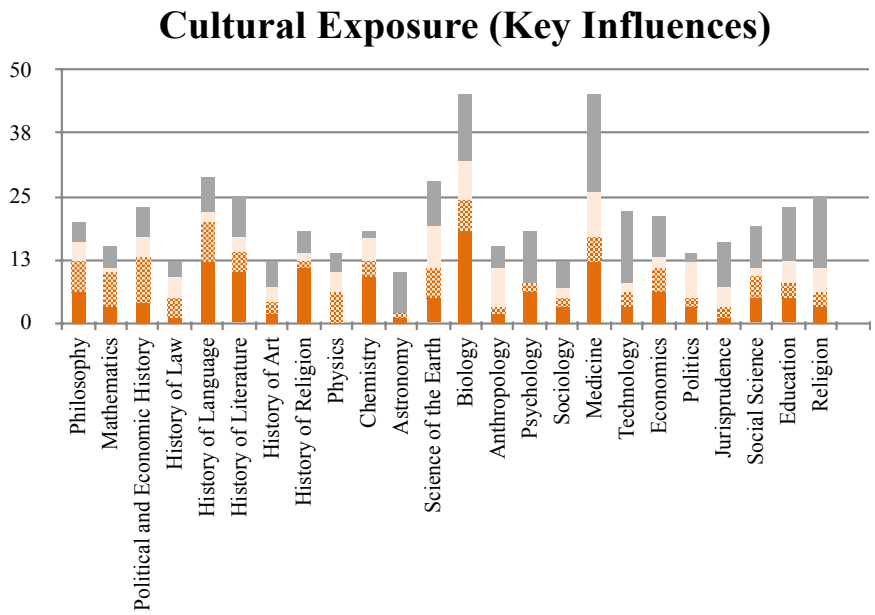

Figure 6.2. Cultural exposure of delegates at the ICAS, 1904.

83 Figure 6.2 uses the participants at ICAS as a self-selected sample. Background information was accumulated on the participants in each department and the figure shows the proportion who had lived, studied and / or worked in Germany as well as those who had lived, studied and / or worked in western North America. For this analysis, western North America includes the Great Plains, the mid-western states, the northwestern coastal states, California, and Texas. The data reflects only information that was readily available in memorials, obituaries and similar online sources, and therefore should be taken as minimum numbers. It does not include, for example, the many American academics who learned German within the family home or studied German in college but did not travel to Europe for post-secondary education. Data for individuals familiar with both Germany and western North America is isolated. In Biology, for example, there were 45 participants on total. Of the 45, 18 participants had lived, studied and / or worked in Germany, and another 6 had lived, studied and / or worked in both Germany and western North America. At least half of everyone involved in the biology section was conversant in German and familiar with recent trends in German biology. This is neither the highest percentage (three quarters of the mathematicians had trained in Germany) or the lowest (one quarter of the participants in the Religion department had a significant experience with Germany). It is interesting that the ratios are similar for earth sciences and for history, the other two cognate fields that contributed to early ecology. The combined totals for all departments are the most telling, however: at least 226 of the Congress participants lived, studied and / or worked in Germany (45%). The figure shows the remainder as a residual category that combines those who spent their careers living and working along the eastern seaboard, Americans who had studied in England or France, and scientists who were based somewhere else in Europe.

History, the study of change and continuity in human societies, and ecology, the study of the relationships between organisms and their environment, became intertwined in the twentieth century. The groundwork for this synthesis between history and ecology was laid in the nineteenth century. Many professional historians and biologists on both sides of the Atlantic were deeply influenced by German scholarship, and came to share basic methodology and terminology. ICAS speakers Charles Bessey, John Merle Coulter and Frederic Clements are examples of prominent botanists who were familiar with German biology and adapted the latest advances in German scientific thought to study their local environment, the North American grasslands. Historians and biologists alike were fascinated by the rapid change that Western society and the environment underwent during the initial settlement period. Varying degrees of social Darwinism and scientific racism was widely evident in many academic communities until the middle of the twentieth century. Investigations into ecology that treated humans as another organism affecting the environment were more fruitful. Similarly, historical studies that included the use and misuse of the environment as another aspect of human society also became popular during this period. One of the earliest examples of an environmental historian is ICAS speaker Frederick Jackson Turner. Since he trained a large cohort of Western-oriented historians, it is unsurprising that when the sub-discipline of environmental history emerged it became closely associated with Western history. The work of his fellow speakers, Franz Boas and the Robinson brothers, also exemplifies leading-edge scholarship produced under the influence of this heady mix of German and Western philosophy and science. By the middle of the twentieth century, the tendency towards interdisciplinarism would enrich both ecology and history so significantly that the new practices could be considered truly modern. Certain academics, including high-profile ecologist Rachel Carson, hardly recognized the studies of the past as belonging the same discipline. The change she identified was not an about-face, however, rather it was an end result of a synthesis occurring between certain networks within the humanities and science. This merging of academic communities was a necessary adaptation for ecology to address the challenges posed to Earth's ecosystems by a fully globalized, industrialized society.

CHAPTER SEVEN

CONCLUSION

This study has examined the centrality of networking in nineteenth-century science. The proceedings of the International Congress of Arts and Science have undeniable value for historians today, but can the event itself be considered a success? The Congress was a success—and a failure. One of the organizers of the ICAS, the lawyer Frederick Holls, had wanted the Congress to involve more than disconnected lectures, and on this basis Münsterberg and the planning committee succeeded tremendously. The scientific lectures at the Congress attempted to create a space where it was possible to look to the past and to the future in an effort to unify disparate branches of science. Most of the speakers were able to go back to the roots of their disciplines and provide insight on how they had branched out and yet still bore similarities, much like any good biologist could do with their species of interest.[1] The speeches were often structured to clarify how a particular branch of science contributed to universal understanding of the physical world. The effect, however, was not necessarily harmonizing. In numerous instances, controversies within the sciences were broached and aired before the public.

By many other measurements, the ICAS proved to be a failure. It certainly failed to unify all knowledge. It failed even to lay a basis for a solution: as historians George Haines and Frederick Jackson have declared, "unification on the academic level was thwarted by an imperialism differing only in degree and methods from that which the political internationalists were encountering."[2] Any unity of knowledge would have to be absorbed by those who purchased the proceedings. Indeed, a great deal of faith was placed in the publication of the proceedings: to leave a mark in the academic world, to form an encyclopedia for lay readers, and/or to offset the enormous costs. Unfortunately, the proceedings sold poorly since they were not useful as an encyclopedia. They did, however, provide a valuable contribution for historical study by academics. In particular,

1 In defense of this indulgence in metaphor, historians of science are prone to appropriating all the wonderful terminology. Turner of course liked his evolution metaphors. More recently, Sharon Kingsland argued that the ecological idea of the "niche," which explains how plant and animal species play certain roles in the ecological community, can be used to discuss scientific disciplines like ecology as well. In the metaphorical sense, individuals with similar needs and roles are said to compete and hence would find it difficult if not impossible to occupy the same niche. She clarifies that the niche does not really exist as a definite place out there in the world, nor is it something that is fixed in time; it is really a shorthand device for thinking about how organisms relate to their environment and how they compete with other organisms for resources. Kingsland has argued that the role and place of a discipline evolves over time in competition with other disciplines and in relation to an environmental and social context. See Sharon Kingsland, *The Evolution of American Ecology, 1890-2000.* (Baltimore: Johns Hopkins University Press), 1-7.

2 George Haines (IV) and Frederick H. Jackson, "A Neglected Landmark in the History of Ideas," *The Mississippi Valley Historical Review* 34, no. 2 (1947), 217.

commentary on scientific activities in America is extensive. This focus was partly because the speakers were eager to compliment their host, but it is also evidence that the American academe was mature and thriving.[3] Geographer Henry Yule Oldham of Cambridge University, for example, constructed his remarks to assert that the center of research and industry was steadily moving westwards away from Europe and now rested in the newly "civilized" regions of middle America. He then suggested that the process would continually repeat itself and that a new "center of gravity" may soon be located along the Pacific coast.[4] His speech also reflected current events, and in particular the growing interest and anxieties of the political and scientific communities concerning geopolitical relationships in the Pacific sphere. The Russo-Japanese conflict had broken out in February of that year and the bounty of science of technology at the Fair, initially intended for educational elucidation, was quickly being reassessed as an opportunity to analyze potential military and industrial rivals.

The Congress was an academic event housed within a politico-cultural event. At the Exposition, the material and intellectual results of scientific and settlement projects undertaken by all the industrial nations were on display. Amid this kaleidoscope of research, industry, and luxury, pavilions from the western states and Canada managed to favorably compete with those from Russia, China, Japan and the industrialized nations of Europe. The cumulative effect was considered to be so overwhelming that numerous safeguards were in place should audience members faint. The lands and products of the Louisiana territories, so poorly understood only a century before, were the centerpiece of a World's Fair that was focused on the concepts of unity, improvement, and progress. The specimen collections and scientific reports amassed during the assessment and development of Western territory were envisioned as the inheritance of the international scientific community, part of an arsenal of new concepts and methodologies that scientists would rely on in the coming century.

ICAS was able to provide a space, literally, for leading scientists to forge connections with one another, and many of them proved eager do to so. By the time the ICAS wrapped up on Friday afternoon with the official banquet, clusters had formed. The official reporter observed a group of high-profile surgeons holding informal discussions "the counterpart of which would be hard to find" and theologians chatting animatedly "as though their religious theories were not as far apart as the poles."[5] The dinner was held in the banquet hall of the Tyrolean Alps at the German

3 A. W. Coats, "American Scholarship Comes of Age: The Louisiana Purchase Exposition 1904," *Journal of the History of Ideas* 22, no. 3 (1961), 417.

4 Henry Yule Oldham, "The Relative Value of Geographical Position," *International Congress of Arts and Science* 8.(London and New York, University Alliance, 1908), 679.

5 Howard Jason Rogers, "History of the Congress," *International Congress of Arts and Science* 1. Ed. Howard Jason Rogers. St. Louis: University Alliance, 1908), 34.

pavilion. Imperial Germany was on display for all the participants. The dining hall was 160 feet by 105 feet, capable of seating 1500 (though 700 attended), and constructed with solid German oak. Murals were painted by leading German painters. A band played on the south end of the hall, and the galleries and boxes were filled with the well-dressed wives of the attendees and of the officials of the Exposition.[6] David Francis and Simon Newcomb made some concluding remarks, and then German Commissioner-General Lewald responded with a self-congratulatory address thanking the Exposition and the American Government for the high honor done the German nation in "selecting so large a percentage of the speakers from German scientific circles." He remarked that this high profile had a base in the close relationship between American and German universities, which arose from the large number of American students who had pursued post-graduate work in Germany.[7]

The French Commissioner-General was intended to speak next but he had begged off sick, likely deliberately, and mathematician Gaston Darboux was delegated to provide a response. Darboux lamented being unable to spend more time with the exhibits, and in particular the agricultural ones. He then waxed eloquent about the universal nature of science and the potential for scientific practice in America, toasting his American hosts in "this beautiful territory of Louisiana, which France in former age ceded freely to America."[8] The Italian representative similarly thanked the hosts and emphasized that his country was the land of Columbus and he was very happy to address his audience in Italian, on American ground. He concluded with a toast to "Science and Peace."[9] The pinnacle of the evening, however, according to the official press of Howard Jason Rogers, was a speech from Nobushige Hozumi from the Faculty of Law at the University of Tokyo. He "delighted in the common plane upon which all nations might meet in the pursuit of science," noting that only for a Congress of such importance could a Japanese and Russian meet in mutual accord during 1904. This declaration brought on a standing ovation.[10]

The delegates began filtering out of the country that weekend, but many stayed for lengthened visits and tours over the next several weeks, and even more maintained correspondence long after the event. On Saturday, a banquet was held for foreign guests by the literal-minded Round Table of St. Louis Club, and another by the Imperial Commissioner-General of Japan, and yet another by Commissioner-General from Great Britain.[11] Most of the foreign guests were the

6 *Ibid*.

7 *Ibid*., 36.

8 *Ibid*., 38.

9 *Ibid*., 39.

10 *Ibid*., 38. The Japanese professor also gave tribute to the educational system of the United States, and the great debt which Japan owed to American scholars and teachers for their aid in establishing modern educational principles and methods in Japan.

11 *Ibid*., 25. The Club possessed a huge round table.

routed back to Europe through Washington, where they stopped for a week to be entertained by members of high society, from Simon Newcomb to the President of the United States. Some of the Germans then traveled north to Boston, where they were received by Münsterberg at Harvard, and provided a farewell dinner by the Association of Old German students at Harvard.[12]

A few of the guests, such as the sociologist Max Weber, created their own itineraries. Weber was initially skeptical about the value of the ICAS. Weber and Münsterberg were colleagues in Freiburg,[13] but Weber was not friendly to Münsterberg's conception of knowledge, and the speech he provided was sharply critical.[14] He also complained bitterly throughout the ostentatious evening ceremonies, yet found he nevertheless had made a number of useful American contacts and he was pleased to participate in a tour of Oklahoma to inquire into the farmers' living conditions.[15] This research trip became the basis of some of his later work in the field. Another attendee that stayed on in the USA was German historian Karl Lamprecht, who visited many American universities in order to spread his message of universal and cultural history.[16] It was later collected as *What Is History*.[17]

Münsterberg was pleased with the results of his Congress, and stressed in his report the opportunity of personal meetings among the leaders in various fields.[18] Münsterberg and his colleague Wilhem Waldeyer went on to establish a professorial exchange between Harvard and Berlin Universities.[19] Münsterberg continued to promote "harmonious international relations through the fostering of cultural ties" and became the first director of the German America Institute in Berlin in 1910.[20] It is said that he was heartbroken when Germany declared war in 1914. He died in 1915, knowing this extended period of science and peace among the industrialized, imperial powers had permanently ended.

---

12 David Zitarelli, "The 1904 St. Louis Congress and Westward Expansion of American Mathematics." *Notices of the American Mathematical Society* 58, no. 8 (2011), 1106.

13 Lawrence Scaff, *Max Weber in America* (Mass.: Princeton University Press, 2011), 55.

14 *Ibid*. The original German version was lost and only a poor English translation remains.

15 *Ibid*., 73. Weber's trip to the Oklahoma territory has been thoroughly discussed by Scaff, with a particular focus on the conception of nature he applied as he observed the Indian territories. See *Max Weber in America*, 73-97.

16 Lynne Tatlock and Matt Erlin, *German Culture in Nineteenth-Century America: Reception, Adaptation, Transformation* (Rochester: Camden House, 2005), 13.

17 Haines and Jackson, "A Neglected Landmark in the History of Ideas," 216.

18 *Ibid.*, 215.

19 Eric Ames. "The Image of Culture - Or, What Munsterberg Saw at the Movies." In Lynne Tatlock and Matt Erlin. *German Culture in Nineteenth-Century America: Reception, Adaptation, Transformation* (Rochester: Camden House, 2005), 23.

20 Haines and Jackson, "A Neglected Landmark in the History of Ideas," 207.

Figure 7.1. Hugo Münsterberg at the ICAS, 1904.[21]

From the words of the early ecologists themselves, it is obvious that ecology was a self-conscious field at the turn of the twentieth century and the participants in the ecology network could identify their own roots at least back to Alexander von Humboldt and his contacts. It is also clear that it was an international network led by Anglo and German scientists that spanned both sides of the Atlantic from the very earliest stage. A connection between German and American life science was forged almost immediately after the completion of the Louisiana Purchase when Humboldt and Jefferson began communicating. North American researchers usually pursued study in Europe during the nineteenth century, but European scientists were also exploring and investing in North America during the same period.

21 Hugo Münsterberg at the LPE. Photograph by Jesse Tarbox Beals. *Popular Science Monthly* Vol 66 (November) 1904. In article by William Harper Davis, "The International Congress of Arts and Science," *Popular Science Monthly* 66, no. November (1904), 26. Public domain.

The early ecological network had received a theoretical impetus from Charles Darwin and his circle, and the widespread interest in natural selection placed the period of professionalization in ecology firmly within the geopolitical context of the British world system. Thus, in 1859 Harvard botanist Asa Gray was vehemently defending Darwin's theory of natural selection in Cambridge, Massachusetts, when English comparative anatomist Thomas Huxley was doing the same in London. The greatest advances in ecology during the 1880s and 1890s were made by botanists, especially those who were involved in agricultural research stations, botanical gardens, and government partnerships. The leader in botanical exchange networks, as with most other scientific knowledge exchange (not to be confused with the production of scientific knowledge) had historically been Britain, not least because it happened to be the homeland of Charles Darwin, but also because of the looming presence of Kew Gardens in botany. Politically, the British empire was also near its peak. Historian John Darwin has argued that during the Victorian period, the British Empire formed the core of a larger British 'world-system' that was managed from London and encompassed a range of constitutional, diplomatic, political, commercial, and cultural relationships that involved a bi-directional flow of knowledge and resources.[22] In 1904, an international event that involved science, like the LPE, *required* British endorsement and securing commitment from the British government was a major factor in its subsequent success.

The philosophical and methodological structure for the rapidly professionalizing field were provided by German biologists between 1860 and 1880, particularly those who communicated internationally, published translations, and reached out to the public, as did Ernst Haeckel. German ideas were also imbibed by the steady stream of anglophone students pursuing advanced degrees in Germany. This combined intellectual heritage was exported to peripheries by the multilingual, mobile international professoriate. At the turn of the twentieth century, Frederic Clements could be found conducting recognizably ecological studies on the grasslands of Nebraska, and was Alfred Giard researching *ethologie* at his station in Wimereux. Neither was aware of any similarities in approach, but they were part of the same network. Major nodes in animal ecology and palaeontology were occupied, however, for over a decade with forays into Lamarckism. The re-discovery of Mendelian genetic principles straightened the course for animal biologists, again on both sides of the Atlantic. When Dutch botanist Hugh de Vries, German geneticist Carl Correns, and Austrian agronomist Erik von Tschermak were famously re-discovering Mendel's law in 1900, American plant scientist William Jasper Spillman was performing the same kind of research on wheat in Oregon. The remarkable similarities in interests, approaches, and challenges that are apparent on both sides of the Atlantic did not occur because they were developing in a parallel fashion, but rather because there was one, expansive network of biologists interested in ecological thought.

22 John Darwin, *The Empire Project: The Rise and Fall of the British World-System, 1830-1970* (Cambridge, UK: Cambridge University Press, 2009), 1.

It is difficult to overstate the influence of Darwin on early ecology, and equally difficult to oversell the important role of the German academy on nineteenth-century American scholarship. The German university system penetrated nearly every American university department in some manner, even American studies. Historian William Brewer emphasized that Frederick Jackson Turner studied at Johns Hopkins, which was then led by Daniel Coit Gillman, an administrator who "had gathered a group of scholars who were recently trained in German Universities." Therefore Turner produced his PhD thesis on a campus "where the best of German scholarship was flowering and gradually spreading to other centers of American learning."[23] There is a considerable overlap between the two networks, of ecology and German-Anglo research, made plain by this study of the hosting of ICAS.

In 1905, the secretary of the ICAS ecology section Frederic Clements published *Research Methods in Ecology*, and gained widespread recognition for putting ecology on a scientific basis.[24] Historian Gregory Cooper has claimed that the monograph represented the first attempt at presenting a comprehensive theoretical framework for ecology. The guiding idea was that the surface of the plant was divided into distinct natural units that were called plant formations. Each unit was defined by a climax community, a community that with sufficient time and in the absence of disturbance would occupy the site. The entire climax community was a function of climate. The climax vegetation of a given area is the only plant community that is able to perpetuate itself in that location; so long as climatic conditions do not change, the climax will remain in stable equilibrium.[25] His theory was backed up by the data analysis he had compiled and analyzed with Roscoe Pound, under the mentorship of Charles Bessey and directly informed by methodological innovations of Oscar Drude. Clement's theory was imperfect. As historian Robert McIntosh has pointed out, the climax formation itself was not actually static but rather indicated the end of a process, a process in which internal structure change progressed in a unidirectional development governed from above by the higher level unit.[26] Clement's ideas are not under review here, however. The ideas he published in 1905 directly reflect the questions being asked by his research circle.

Ecological thought had been developing for over a century, and it would continue to coalesce throughout the twentieth century. The history of ecology resists any attempt to place a launch date, identify a single father figure, or even be subjected to periodization. Rather, the roots of ecology are diverse and interdisciplinary, and that tendency accelerated from its earliest days as ecological thought in biology has merged with the study of human history and political environmentalism.

---

23 Brewer, "The Historiography of Frederick Jackson Turner," 243.

24 Cooper, *The Science of the Struggle for Existence*, 39.

25 *Ibid*.

26 McIntosh, *The Background of Ecology*, 85.

Ecology in the nineteenth century was an undertaking that sprawled, both intellectually and geographically. Restricting the scope to that of the attendees of the ICAS provided both focus and limitations. This discussion has confirmed that the role of women and amateurs within ecological circles is underrepresented in the historiography. Using a social network approach is a viable method to identify these individuals. Having isolated the leading role of botanists and their social circle in early ecology through this analysis, the next step would be to flesh out these connections using additional source material. Alternative perspectives on the history of ecology from academics that were excluded or unable to attend should be sought out, so that the material presented in the lectures can be critically examined. Crossatlantic and interdisciplinary connections in Europe and North America could be pursued further, and the impact of researchers working in South America, Australia, Africa and Asia would need to be considered. Study of early ecology must maintain a broad viewpoint. Scientific ecology did not emerge out of the work of any single naturalist or the publication of a methodological textbook, but rather because ecological thinkers were able to form a successful network that researched questions that mattered to science and society at the time. This ability to adapt has been key to its new prominence, but it is not surprising. After all, ecology, both field and subject, is entirely about change and survival under challenging conditions.

APPENDIX A

Participants in the International Congress of Arts and Science, St. Louis, September 1904

The congress executive is listed first, followed by keynote speakers who addressed the whole assembly in the opening sessions. Then the participants are listed (chairs, speakers and secretaries), organized by department and then alphabetically. The individuals below have been identified from the incomplete information offered in the proceedings, but here the full names are provided, misspelled names are corrected, and dates for birth and death are added wherever possible. There are instances were individuals participated in more than one session; their names are included in each relevant Department.

Congress Executive

Francis, David Rowland (1850-1927). Louisiana Purchase Exposition President.

Rogers, Howard Jason (1861-1927). Louisiana Purchase Exposition Director.

Butler, Nicholas Murray (1862-1947). Administrative Board member, representing Columbia University.

Harper, William Rainey (1856-1906). Administrative Board member, representing the University of Chicago.

Jesse, Richard Henry (1853-1921). Administrative Board member, representing the University of Missouri.

Pritchett, Henry Smith (1857-1939). Administrative Board member, representing Massachusetts Institute of Technology.

Putnam, George Herbert (1861-1955). Administrative Board member, representing the Library of Congress.

Skiff, Frederick James Volney (1851-1921). Administrative Board member, representing the Field Columbian Museum.

Newcombe, Simon (1835-1909). ICAS President, retired astronomer and mathematician.

Münsterberg, Hugo (1863-1916). ICAS Vice-President, representing Harvard University.

Small, Albion (1854-1926). ICAS Vice-President, representing the University of Chicago.

Howard, Leland Ossian (1849-1928). Executive Secretary, representing the American Association for the Advancement of Science.

Bryce, James (1838-1922). Honorary Vice-President, representing Great Britain.

Darboux, Jean Gaston (1842-1917). Honorary Vice-President, representing France.

Waldeyer, Wilhelm (1836-1921). Honorary Vice-President, representing Germany.

Backlund, Johan Oskar (1846-1916). Honorary Vice-President, representing Russia.

Escherich, Theodore (1857-1911). Honorary Vice-President, representing Austria.

Brunialti, Attilio (1849-1920). Honorary Vice-President, representing Italy.

Nobushige, Hozumi (1855-1926). Honorary Vice-President, representing Japan.

Keynote Speakers

Division A (Normative Science). Josiah Royce (1855-1916), representing Harvard University, USA.

Division B (Historical Science). Thomas Woodrow Wilson (1856-1924), representing Princeton University, USA.

Division C (Physical Science). Robert Simpson Woodward (1849-1924), representing Columbia University, USA.

Division D (Mental Science). Granville Stanley Hall (1846-1924), representing Clark University, USA.

Division E (Utilitarian Science). David Starr Jordan (1851-1931), representing Leland Stanford Jr. University, USA.

Division F (Social Regulation). Abbott Lawrence Lowell (1856-1943), representing Harvard University, USA.

Division G (Social Culture). William Torrey Harris (1835-1909), United States Commissioner of Education.

Division A Normative Science

Department 1 - Philosophy

Armstrong, Andrew Campbell (1860-1935). Representing Wesleyan University, USA.

Bowne, Borden Parker (1847-1910). Representing Boston University, USA.

Creighton, James Edwin (1861-1924). Representing Cornell University, USA.

Dessoir, Max (1867-1947). Representing the University of Berlin, Germany.

Duncan, George Martin (1857-1928). Representing Yale University, USA.

Erdmann, Benno (1851-1921). Representing the University of Bonn, Germany.

Hall, Thomas Cuming (1858-1936). Representing the Union Theological Seminary, USA.

Hammond, William Alexander (1861-1938). Representing Cornell University, USA.

Hensel, Paul (1860-1930). Representing the University of Erlangen, Germany.

Howison, George Holmes (1834-1916). Representing the University of California, USA.

Ladd, George Trumbull (1842-1921). Representing Yale University, USA.

Lovejoy, Arthur Oncken (1873-1962). Representing Washington University, USA.

Marshall, Henry Rutgers (1852-1927). Representing New York City, USA.

Meyer, Max Friedrich (1873-1967). Representing the University of Missouri, USA.

Montague, William Pepperell (1873-1953). Representing Columbia University, USA.

Ormond, Alexander Thomas (1847-1915). Representing Princeton University, USA.

Ostwald, Fredrich Wilhem (1853-1932). Representing the University of Leipzig, Germany.

Palmer, George Herbert (1842-1933). Representing Harvard University, USA.

Perry, Ralph Barton (1876-1957). Representing Harvard University, USA.

Pfleiderer, Otto (1839-1908). Representing the University of Berlin, Germany.

Sharp, Frank Chapman (1866-1943). Representing the University of Wisconsin, USA.

Sheldon, William Henry (1875-1977). Representing Columbia University, USA.

Sorley, William Ritchie (1855-1935). Representing the University of Cambridge, Great Britain.

Taylor, Alfred Edward (1869-1945). Representing McGill University, Canada.

Troeltsch, Ernst (1865-1923). Representing the University of Heidelberg, Germany.

Tufts, James Hayden (1862-1942). Representing the University of Chicago, USA.

Woodbridge, Frederick James Eugene (1867-1940). Representing Columbia University, USA.

Department 2 - Mathematics

Bliss, Gilbert Ames (1876-1951). Representing the University of Chicago, USA.

Bôcher, Maxime (1867-1918). Representing Harvard University, USA.

Boltzmann, Ludwig (1844-1906). Representing the University of Vienna, Austria.

Darboux, Jean Gaston (1842-1917). Representing Academy of Sciences, Paris, France.

Eddy, Henry Turner (1844-1921). Representing the University of Minnesota, USA.

Haskell, Mellen Woodman (1863-1948). Representing the University of California, USA.

Holgate, Thomas Franklin (1859-1945). Representing Northwestern University, USA.

Kasner, Edward (1878-1955). Representing Columbia University, USA.

Maschke, Heinrich (1853-1908). Representing the University of Chicago, USA.

Moore, Eliakim Hastings (1862-1932). Representing the University of Chicago, USA.

Picard, Charles Émile (1856-1941). Representing the Sorbonne, France.

Pierpont, James P. (1866-1938). Representing Yale University, USA.

Poincaré, Jules Henri (1854-1912). Representing the Sorbonne, France.

Webster, Arthur Gordon (1863-1923). Representing Clark University, USA.

White, Henry Seeley (1861-1943). Representing Northwestern University, USA.

Division B – Historical Science

Department 3 – Political and Economic History

Adams, George Burton (1851-1925). Representing Yale University, USA.

Bourne, Edward Gaylord (1860-1908). Representing Yale University, USA.

Bury, John Bagnell (1861-1927). Representing the University of Cambridge, Great Britain.

Capps, Edward (1866-1950). Representing the University of Chicago, USA.

Colby, Charles William (1867-1955). Representing McGill University, Canada.

Conrad, Johann (1839-1915). Representing the University of Halle, Germany.

Cordier, Henri (1849-1925). Representing the Ecole des Langues Vivantes Orientales, France.

Dowe, Earle Wilbur (1868-1946). Representing the University of Michigan, USA.

Fetter, Frank Albert (1863-1949). Representing Cornell University, USA.

Greene, Evarts Boutell (1870-1947). Representing the University of Illinois, USA.

Haskins, Charles Homer (1870-1937). Representing Harvard University, USA.

Lamprecht, Karl Gotthard (1856-1915). Representing the University of Leipzig, Germany.

Mahaffy, John Pentland (Sir) (1839-1919). Representing the University of Dublin, Ireland.

Norton, J. Pease (1877-1952). Representing Yale University, USA.

Pais, Ettore (1856-1939). Representing the University of Naples, Italy.

Patton, Simon Nelson (1852-1922). Representing the University of Pennsylvania, USA.

Perkins, James Breck (1847-1910). Congressman from Rochester, NY, USA.

Robinson, James Harvey (1863-1936). Representing Columbia University, USA.

Schevill, Ferdinand (1868-1954). Representing the University of Chicago, USA.

Schouler, James (1839-1920). Private citizen from Boston, MA, USA.

Seymour, Thomas Day (1848-1907). Representing Yale University, USA.

Sloane, William Milligan (1850-1928). Representing Columbia University, USA.

Turner, Frederick Jackson (1861-1932). Representing the University of Wisconsin, USA.

Department 4 – History of Law

Abbott, Nathan (1854-1941). Representing Leland Stanford Jr. University, USA.

Baldwin, Simeon Eben (1840-1927). Judge of the Supreme Court of Errors, New Haven, USA.

Brewer, David Josiah (1837-1910). Associate Justice of the Supreme Court of the USA.

Buckler, William Hepburn (1867-1952). Representing Baltimore, MD, USA.

Dickinson, Jacob McGavock (1851-1928). Representing Chicago, USA.

Hozumi, Nobushige (1855-1926). Representing the University of Tokyo, USA.

Huberich, Charles Henry (1877-1945). Representing the University of Texas, USA.

Lawson, John Davidson (1875-1922). Representing the University of Missouri, USA.

McClain, Emlin (1851-1915). Judge of the Supreme Court of Iowa, USA.

Nerincx, Alfred (1872-1943). Representing the University of Louvain, Belgium.

Smith, Edmund Munroe (1854-1926). Representing Columbia University, USA.

Wigmore, John Henry (1863-1943). Representing Northwestern University, USA.

Department 5 – History of Language

Brandon, Edgar Ewing (1865-1957). Representing Miami University, USA.

Buck, Carl Darling (1866-1955). Representing the University of Chicago, USA.

Collitz, Herman (1855-1935). Representing Bryn Mawr College, USA.

Craig, James Alexander (1855-1932). Representing the University of Michigan, USA.

D'Ooge, Martin Luther (1839-1915). Representing the University of Michigan, USA.

Fay, Edwin Whitfield (1865-1920). Representing the University of Texas, USA.

Gayley, Charles Mills (1858-1932). Representing the University of Chicago, USA.

Hale, William Gardner (1849-1928). Representing the University of Chicago, USA.

Harry, Joseph Edward (1863-1949). Representing the University of Cincinnati, USA.

Hempl, George (1859-1906). Representing the University of Michigan, USA.

Humphreys, Milton W. (1844-1928). Representing the University of Virginia, USA.

Hutton, Maurice (1856-1940). Representing the University of Toronto, Canada.

Jespersen, Jens Otto (1860-1943). Representing the University of Copenhagen, Denmark.

Karsten, Gustaf E. (1859-1908). Representing Cornell University, USA.

Kittredge, George Lyman (1860-1941). Representing Harvard University, USA.

Levi, Sylvain (1863-1935). Representing the College de France, France.

Lounsbury, Thomas Rayneford (1838-1915). Representing Yale University, USA.

Macdonell, Arthur Anthony (1854-1930). Representing the University of Oxford, Britain.

March, Francis Andrew (1825-1911). Representing Lafayette College, USA.

Meyer, Marie-Paul-Hyacinthe (1840-1917). Representing the College de France, France.

Moore, George Foot (1851-1931). Representing Harvard University, USA.

Oertel, Hanns (1868-1952). Representing Yale University, USA.

Shipley, Frederick William (1871-1945). Representing Washington University, USA.

Sievers, Eduard (1850-1932). Representing the University of Leipzig, Germany.

Smyth, Herbert Weir (1857-1937). Representing Harvard University, USA.

Sonnenschein, Edward (1851-1926). Representing the University of Birmingham, Great Britain.

Todd, Henry Alfred (1854-1925). Representing Columbia University, USA.

Toy, Crawford Howell (1836-1919). Representing Harvard University, USA.

Wheeler, Benjamin Ide (1854-1927). Representing the University of California, USA.

Department 6 – History of Literature

Bloomfield, Maurice (1855-1928). Representing Johns Hopkins University, USA.

Boyer, Paul (1864-1949). Representing the École des Langues Vivantes Orientales, France.

Cohn, Adolphe (1851-1930). Representing Columbia University, USA.

Comfort, Howard (1850-1912). Representing Haverford College, USA.

Crane, Charles Richard (1858-1939). Private citizen from Chicago, USA.

Fortier, Alcée (1856-1914). Representing Tulane University, USA.

Francke, Kuno (1855-1930). Representing Harvard University, USA.

Gayley, Charles Mills (1858-1932). Representing the University of California, USA.

Gummere, Francis Barton (1855-1919). Representing Haverford College, USA.

Harper, Samuel Northrup (1882-1943). Representing the University of Chicago, USA.

Harrison, James Albert (1848-1911). Representing the University of Virginia, USA.

Herrick, Robert (1868-1938). Representing the University of Chicago, USA.

Hoops, Johannes (1865-1949). Representing the University of Heidelberg, Germany.

Jackson, Abraham Valentine Williams (1862-1937). Representing Columbia University, USA.

Jessen, Karl Detlev (1872-1919). Representing Bryn Mawr College, USA.

Matthews, James Brander (1852-1929). Representing Columbia University, USA.

Minor, Jakob (1855-1912). Representing the University of Vienna, Austria.

Moore, Frank Gardner (1865-1955). Representing Dartmouth College, USA.

Rajna, Pio (1847-1930). Representing the Institute of Higher Studies, Italy.

Sauer, August (1855-1926). Representing the University of Prague, Austria-Hungary.

Schofield, William Henry (1870-1920). Representing Harvard University, USA.

Shorey, Paul (1857-1934). Representing the University of Chicago, USA.

West, Andrew Fleming (1853-1943). Representing Princeton University, USA.

Wiener, Leo (1862-1939). Representing Harvard University, USA.

Wright, John Henry (1852-1908). Representing Harvard University, USA.

Department 7 – History of Art

Baur, Paul Victor Christopher (1872-1951). Representing Yale University, USA.

Enlart, Camille (1862-1927). Representing Universite-de-Paris, France.

Furtwängler, Adolph (1853-1907). Representing University of Munich, Germany.

Hamlin, Alfred Dwight Foster (1855-1926). Representing Columbia University, USA.

Ives, Halsey Cooley (1847-1911). Representing Washington University, USA.

Okakura, Kakuzō, (1862-1913). Representing Japan.

Lowell, Guy (1870-1927). Representing Boston, MA, USA.

McKim, Charles Follen (1847-1909). Private citizen from New York City, USA.

Muther, Richard (1860-1909). Representing University of Breslau, Germany.

Richardson, Rufus Byam (1845-1914). Representing New York City, USA.

Tarbell, Frank Bigelow (1852-1920). Representing the University of Chicago, USA.

Van Dyke, John Charles (1861-1931). Representing Rutgers College, USA.

Department 8 – History of Religion

Bacon, Benjamin Wisner (1860-1932). Representing Yale University, USA.

Bloomfield, Maurice (1855-1928). Representing Johns Hopkins University, USA.

Budde, Karl Ferdinand Reinhard (1850-1935). Representing the University of Marburg, Germany.

Burton, Ernest DeWitt (1856-1925). Representing the University of Chicago, USA.

Currier, Augustus (b. and d. unknown). Representing the McCormick Theological Seminary, USA.

Goldziher, Ignác (1850-1921). Representing the University of Budapest, Romania.

Griffis, William Eliot (1843-1928). Private citizen from Ithaca, New York, USA.

Hulbert (II), Eri Baker (1841-1907). Representing the University of Chicago, USA.

Jewett, James Richard (1862-1943). Representing the University of Chicago, USA.

Kelso, James Anderson (1873-1951). Representing the Western Theological Seminary, USA.

Macdonald, Duncan Black (1862-1943). Representing the Hartford Theological Seminary, USA.

McCurdy, James F. (1867-1939). Representing the University of Toronto, Canada.

Moore, George Foot (1851-1931). Representing Harvard University, USA.

Oldenberg, Hermann (1854-1920). Representing the University of Kiel, Germany.

Réville, Jean (1854-1908). Representing the Protestant Faculty of Theology, France.

Robbins, Reginald Chauncey (1871-1955). Representing Harvard University, USA.

Schmidt, Nathaniel (1862-1939). Representing Cornell University, USA.

von Harnack, Adolf (1851-1930). Representing the University of Berlin, Germany.

Votaw, Clyde Weber (1864-1946). Representing the University of Chicago, USA.

Zenos, Andrew Constantinides (1855-1942). Representing the McCormick Theological Seminary, USA.

Division C – Physical Science

Department 9 - Physics

Barus, Carl (1856-1935). Representing Brown University, USA.

Brace, DeWitt Bristol (1859-1905). Representing the University of Nebraska, USA.

Crew, Henry (1859-1953). Representing the Northwestern University, USA.

Humphreys, William Jackson (1862-1949). Representing the University of Virginia, USA.

Kimball, Arthur Lalanne (1856-1922). Representing Amherst College, USA.

Langevin, Paul (1872-1946). Representing the Collège de France, France.

Milliken, Robert Andrews (1868-1953). Representing the University of Chicago, USA.

Nichols, Edward Leamington (1854-1937). Representing Cornell University, USA.

Nipher, Francis Eugene (1847-1926). Representing Washington University, USA.

Rutherford, Ernest (1871-1937). Representing McGill University, Canada.

Stratton, Samuel Wesley (1861-1931). Representing the National Bureau of Standards, USA.

Trowbridge, Augustus (1870-1934). Representing the University of Wisconsin, USA.

Webster, Arthur Gordon (1863-1923). Representing Clark University, USA.

Department 10 - Chemistry

Alsberg, Carl Lucas (1877-1940). Representing Harvard University, USA.

Atwater, Wilbur Olin (1844-1907). Representing Wesleyan University, USA.

Bancroft, Wilder Dwight (1867-1953). Representing Cornell University, USA.

Chittenden, Russell Henry (1856-1943). Representing Yale University, USA.

Clarke, Frank Wigglesworth (1847-1931). Representing the US Geological Survey, USA.

Cohnheim, Otto (1873-1953). Representing the University of Heidelberg, Germany.

Crafts, James Mason (1839-1917). Representing the Massachusetts Institute of Technology, USA.

Dudley, William Lofland (1859-1915). Representing Vanderbilt University, USA.

Mallet, John W. (1832-1912). Representing the University of Virginia, USA.

Moissan, Henri (1852-1907). Representing the Sorbonne, France.

Nef, John Ulric (1862-1915). Representing the University of Chicago, USA.

Noyes, Arthur Amos (1866-1936). Representing the Massachusetts Institute of Technology, USA.

Noyes, William Albert (1879-1941). Representing the National Bureau of Standards, USA.

Prescott, Albert Benjamin (1832-1905). Representing the University of Michigan, USA.

Ramsay, William (1852-1916). Representing the Royal Institution, London, Great Britain.

Stieglitz, Julius (1867-1937). Representing the University of Chicago, USA.

van't Hoff, Jacobus Henricus (1852-1911). Representing the University of Berlin, Germany.

Whitney, Willis Rodney (1868-1958). Non-resident Associate Professor at the Massachusetts Institute of Technology.

Department 11 - Astronomy

Adams, Walter Sydney Adams (1876-1956). Representing the Yerkes Observatory, USA.

Boss, Lewis (1846-1912). Representing the Dudley Observatory, USA.

Campbell, William W. (1862-1938). Representing the Lick Observatory, USA.

Comstock, George Cary (1855-1934). Representing the Wisconsin Observatory, USA.

Eichelberger, William Snyder (1865-1954). Representing the US Naval Observatory, USA.

Hale, George Ellery (1868-1939). Representing the Yerkes Observatory, USA.

Kapteyn, Jacobus Cornelius (1851-1851). Representing the University of Groningen, Netherlands.

Pickering, Edward Charles (1846-1919). Representing the Harvard Observatory, USA.

Stone, Ormond (1847-1933). Representing the University of Virginia, USA.

Turner, Herbert Hall (1861-1930). Representing the University of Oxford, Great Britain.

Department 12 – Sciences of the Earth

Arrhenius, Svante (1859-1927). Representing the University of Stockholm, Sweden.

Bartlett, John Russell (1843-1904). Representing US Navy, USA.

Bauer, Louis Agricola (1865-1932). Representing the Carnegie Institution, USA.

Becker, George Ferdinand (1847-1919). Representing the US Geological Survey, USA.

Chamberlin, Thomas Chrowder (1843-1928). Representing the University of Chicago, USA.

Clarke, John Mason (1857-1925). Private citizen from Albany, New York, USA.

Davis, William Morris (1850-1934). Representing the Harvard University, USA.

Farrington, Oliver Cummings (1864-1934). Representing the Field Columbian Museum, USA.

Gannett, Henry (1846-1914). Representing the US Geological Survey, USA.

Gilbert, Grove Karl (1843-1918). Representing the US Geological Survey, USA.

Hall, Christopher Webber (1845-1911). Representing the University of Minnesota, USA.

Lehnerts, Edward M. (1873-unknown). Representing the Minnesota State Normal School, USA.

Mill, Hugh Robert (1861-1950). Representing the Royal Geographical Society, Great Britain.

Mitsukuri, Kakichi (1857-1909). Representing the University of Tokyo, Japan.

Murray, John (Sir) (1841-1914). Private citizen from Edinburgh, Scotland.

Nipher, Francis Eugene (1847-1926). Representing Washington University, USA.

Oldham, Henry Yule (1862-1951). Representing Cambridge University, Great Britain.

Osborn, Henry Fairfield (1857-1935). Representing Columbia University, USA.

Penck, Albrecht (1858-1945). Representing the University of Vienna, Austria.

Rotsch, Abbott Lawrence (1861-1912). Representing the Blue Hill Observatory, USA.

Russell, Israel Cook (1852-1906). Representing the University of Michigan, USA.

Salisbury, Rollin Daniel (1858-1922). Representing the University of Chicago, USA.

Scott, William Berryman (1859-1947). Representing Princeton University, USA.

van Hise, Charles Richard (1857-1918). Representing the University of Washington, USA.

Woodward, Arthur Smith (1864-1944). Representing British Museum of Natural History, Great Britain.

Zirkel, Ferdinand (1838-1912). Representing the University of Liepzig, Germany.

Department 13 - Biology

Arthur, Joseph Charles (1850-1942). Representing Purdue University, USA.

Barnes, Charles Reid (1858-1910). Representing the University of Chicago, USA.

Bessey, Charles Edwin (1845-1915). Representing the University of Nebraska, USA.

Bower, Frederick Orpen (1855-1948). Representing the University of Glasgow, Britain.

Brooks, William Keith (1848-1908). Representing Johns Hopkins University, USA.

Clements, Frederic Edward (1874-1945). Representing the University of Nebraska, USA.

Coulter, John Merle (1851-1928). Representing the University of Chicago, USA.

Davenport, Charles Benedict (1866-1944). Representing the University of Chicago, USA.

de Vries, Hugo (1848-1935). Representing the University of Amsterdam, Netherlands.

Delage, Yves (1854-1920). Representing the Sorbonne, France.

Donaldson, Henry Herbert (1857-1938). Representing the University of Chicago, USA.

Drude, Carl George (Oscar) (1852-1933). Representing the Dresden Technical University, Germany.

Duggar, Benjamin Minge (1872-1956). Representing the University of Michigan, USA.

Ernst, Harold Clarence (1856-1922). Representing Harvard University, USA.

Farlow, William Gilson (1844-1919). Representing Harvard University, USA.

Gage, Simon Henry (1851-1944). Representing Cornell University, USA.

Giard, Alfred Mathieu (1846-1908). Representing the Sorbonne, France.

Herrick, Charles Judson (1868-1960). Representing Denison University, USA.

Hertwig, Oskar (1849-1922). Representing the University of Berlin, Germany.

Hiss, Philip Hanson (1868-1913). Representing Columbia University, USA.

Howard, Leland Ossian (1857-1950). Representing the US Department of Agriculture, USA.

Howell, William Henry (1860-1945). Representing Johns Hopkins University, USA.

Hunt, Reid (1870-1948). Private citizen from Washington, DC, USA.

Jordan, Edwin Oakes (1866-1936). Representing the University of Chicago, USA.

Lee, Thomas G. (birth and death unknown). Representing the University of Minnesota, USA.

Lloyd, Francis Ernest (1868-1947). Representing Columbia University, USA.

Loeb, Jacques (1859-1924). Representing the University of California, USA.

McMurrich, James Playfair (1859-1939). Representing the University of Michigan, USA.

Meltzer, Samuel James (1851-1920). Private citizen from New York City, USA.

Morgan, Thomas Hunt (1866-1945). Representing Columbia University, USA.

Newcombe, Frederick Charles (1858-1927). Representing the University of Michigan, USA.

Piersol, George Arthur (1856-1924). Representing the University of Pennsylvania, USA.

Ritter, William Emerson (1856-1944). Representing the University of California, USA.

Robinson, Benjamin Lincoln (1864-1935). Representing Harvard University, USA.

Shear, Cornelius Lott (1865-1956). Representing the USDA, USA.

Smith, Theobald (1859-1934). Representing Harvard University, USA.

Terry, Robert James (1871-1966). Representing Washington University, USA.

Trelease, William (1857-1945). Representing Washington University, USA.

Verworn, Max (1863-1921). Representing the University of Göttingen, Germany.

von Goebel, Karl Ritter (1855-1932). Representing the University of Munich, Germany.

Waite, Merton Benway (1865-1945). Representing the USDA, USA.

Waldeyer, Wilhelm (1836-1921). Representing the University of Berlin, Germany.

Ward, Henry Baldwin (1865-1945). Representing the University of Nebraska, USA.

Whitman, Charles Otis (1842-1910). Representing the University of Chicago, USA.

Wiesner, Julius (1838-1916). Representing the University of Vienna, Austria.

Department 14 - Anthropology

Boas, Franz (1858-1942). Representing Columbia University, USA.

Chavero, Alfredo (1841-1906). Representing the National Museum, Mexico.

Dorsey, George Amos (1868-1931). Representing the Field Columbian Museum, USA.

Fletcher, Alice (1838-1923). Representing the Washington Anthropological Society, USA.

Haddon, Alfred Cort (1855-1940). Representing the University of Cambridge, Great Britain.

Manouvrier, Léonce-Pierre (1850-1927). Representing the School of Anthropology, France.

McGee, William John (1853-1912). Representing the American Anthropological Association, USA.

Mills, William Corless (1860-1928). Representing the Ohio State University, USA.

Putnam, Frederick Ward (1839-1914). Representing Harvard University, USA.

Saville, Marshall Howard (1967-1935). Representing American Museum of Natural History, USA.

Seler, Eduard Georg (1849-1922). Representing the University of Berlin, Germany.

Shipley, Frederick William (1871-1945). Representing Washington University, USA.

Spitzka, Edward Anthony (1876-1922). Private citizen from New York City, New York, USA.

Spitzka, Edward Charles (1852-1914). Private citizen from New York City, New York, USA.

Starr, Frederick (1858-1933). Representing the University of Chicago, USA.

Division D – Mental Science

Department 15 - Psychology

Baldwin, James Mark (1861-1934). Representing Johns Hopkins University, USA.

Calkins, Mary Whiton (1863-1930). Representing Wellesley College, USA.

Cattell, James McKeen (1860-1944). Representing Columbia University, USA.

Cowles, Edward (1837-1919). Private citizen from Waverley, MA, USA.

Davis, William Henry (1872-d. unknown). Representing Lehigh University, USA.

Høffding, Harald (1843-1931). Representing the University of Copenhagen, Denmark.

Janet, Pierre Marie Félix (1859-1947). Representing College de France, France.

MacDougal, Robert (1866-1939). Representing New York University, USA.

Meyer, Adolph (1866-1950). Private citizen from New York City, USA.

Morgan, Conwy Lloyd (1852-1936). Representing the University College, Bristol, Great Britain.

Pace, Edward A. (1861-1938). Representing the Catholic University of America, USA.

Prince, Morton Henry (1854-1929). Private citizen from Boston, MA, USA.

Royce, Josiah (1855-1916). Representing Harvard University, USA.

Sanford, Edmund Clark (1859-1924). Representing Clark University, USA.

Titchener, Edward Bradford (1867-1927). Representing Cornell University, USA.

Ward, James (1843-1925). Representing Cambridge University, Great Britain.

Woodworth, Robert Sessions (1869-1962). Representing Columbia University, USA.

Yerkes, Robert Mearns (1876-1956). Representing Harvard University, USA.

Department 16 - Sociology

Blackmar, Frank Wilson (1854-1931). Representing the University of Kansas, USA.

Dowd, Jerome (1864-1952). Representing the University of Wisconsin, USA.

Ellwood, Charles Abram (1873-1946). Representing the University of Missouri, USA.

Giddings, Franklin Henry (1855-1931). Representing Columbia University, USA.

Hayes, Edward Cary (1868-1928). Representing Miami University, USA.

Moore , Frederick W. (1863-1911). Representing Vanderbilt University, USA.

Ratzenhofer, Gustav (1842-1904). Field Marshal from Vienna, Austria.

Ross, Edward Alsworth (1866-1951). Representing the University of Nebraska, USA.

Thomas, William Isaac (1863-1947). Representing the University of Chicago, USA.

Tönnies, Ferdinand J. (1855-1936). Representing the University of Kiel, Germany.

Vincent, George Edgar (1864-1941). Representing the University of Chicago, USA.

Ward, Lester Frank (1841-1913). Representing the US National Museum, USA.

Division E – Utilitarian Sciences

Department 17 - Medicine

Adams, Samuel Shugert (1853-1928). Private citizen from Washington, DC, USA.

Allbutt, Thomas Clifford (1836-1925). Representing Cambridge University, Great Britain.

Barker, Lewellys Franklin (1867-1944). Representing the University of Chicago, USA.

Beck, Carl (1856-1911). Representing the Post-Graduate Medical School, New York, USA.

Billings, Frank (1854-1932). Representing the University of Chicago, USA.

Binnie, John Fairbairn (1863-1936). Private citizen from Kansas City, Missouri, USA.

Bracken, Henry Martyn (1854-1938). Private citizen from St. Paul, Minnesota, USA.

Brunton, Thomas Lauder (Sir) (1844-1916). Private citizen from London, Great Britain.

Cabot, Richard Clarke (1868-1939). Private citizen from Boston, MA, USA.

Chaddock, C.G. (1861-1936). Private citizen from St. Louis, MO, USA.

Councilman, William Thomas (1854-1933). Representing Harvard University, USA.

Cowles, Edward (1837-1919). Private citizen from Waverly, Massachusetts, USA.

Dana, Charles Loomis (1852-1935). Representing Cornell University, USA.

Dennis, Frederick S. (1850-1934). Representing the Cornell Medical College, USA.

Escherich, Theodore (1857-1911). Representing the University of Vienna, Austria.

Favill, Henry Baird (1860-1916). Private citizen from Chicago, Illinois, USA.

Flexner, Simon (1863-1946). Representing the Rockerfeller Institute, USA.

Glasgow, William Carr (1845-1907). Representing Washington University, USA.

Gould, George Milbery (1848-1922). Private citizen from Philadelphia, PA, USA.

Hare, Hobart Amory (1862-1931). Representing the Jefferson Medical College, USA.

Harlan, George Cuvier (1858-1909). Private citizen from Philadelphia, PA, USA.

Hektoen, Ludvig (1863-1951). Representing the University of Chicago, USA.

Hurty, John Newell (1852-1925). Private citizen from Indianapolis, Indiana, USA.

Jackson, Edward (1856-1942). Private citizen from Denver, Colorado, USA.

Jacobi, Abraham (1830-1919). Representing Columbia University, USA.

Kelly, Howard Atwood (1858-1943). Representing Johns Hopkins University, USA.

Kitasato, Shibasaburō (1853-1931). Representing the University of Tokyo, USA.

Lederle, Ernst Joseph (1865-1921). Former Commissioner of Health, New York City, USA.

Liebreich, Oscar (1839-1908). Representing the University of Berlin, Germany.

Mathews, Joseph McDowell (1847-1928). State Board of Health, Louisville, Kentucky, USA.

Noble, George Henry (1860-1932). Private citizen from Atlanta, GA, USA.

Orth, Johannes (1847-1923). Representing the University of Berlin, Germany.

Osler, William (1849-1919). Representing Johns Hopkins University, USA.

Putnam, James Jackson (1846-1918). Representing Harvard University, USA.

Ross, Ronald (1857-1932). Representing the University College (Liverpool), Great Britain.

Rotch, Thomas Morgan (1849-1914). Representing Harvard University, USA.

Sedgwick, William (1855-1921). Representing the Massachusetts Institute of Technology, USA.

Semon, Felix (Sir) (1849-1921). Physician Extraordinary to His Majesty, London, Great Britain.

Shattuck, Frederick Cheever (1847-1929). Representing Harvard University, USA.

Sweet , William Merrick (1860-1926). Representing the Jefferson Medical College, USA.

Thayer, William Sydney (1864-1932). Representing Johns Hopkins University, USA.

Webster, John Clarence (1863-1950). Representing Rush Medical College, USA.

Wyman, Walter (1848-1911). Representing the US Marine Hospital Service, USA.

Department 18 – Technology

*This department was effectively for engineers and agriculturists.

Bailey, Liberty Hyde (1858-1954). Representing Cornell University, USA.

Benjamin, Marcus (1857-1932). Representing the US National Museum, USA.

Bovey, Henry Taylor (1852-1912). Representing McGill University, Canada.

Burr, William Hubert (1851-1934). Representing Columbia University, USA.

Chaplin, Winfield Scott (1847-1918). Representing Washington University, USA.

Christy, Samuel Benedict (1853-1914). Representing the University of California, USA.

Dabney, Charles William (1855-1945). Representing the University of Cincinnati, USA.

Denton, James Edgar (1855-unknown). Representing the Stevens Institute of Technology, USA.

Dinkel, George W. (1865-1919). Private citizen from Jersey City, USA.

Hammond, John Hays (1855-1936). Private citizen from New York City, New York, USA.

Haupt, Lewis Muhlenberg (1844-1937). Private citizen from Philadelphia, PA, USA.

Hering, Carl (1860-1926). Private citizen from Philadelphia, PA, USA.

Hill, William (birth and death unknown). Representing the University of Chicago, USA.

Kennelly, Arthur Edwin (1861-1939). Representing Harvard University, USA.

Munroe, Charles Edward (1849-1938). Representing George Washington University, USA.

Pupin, Mihajlo Idvorski (1858-1935). Representing Columbia University, USA.

Richards, Robert (1844-1945). Representing the Massachusetts Institute of Technology, USA.

Smith, Albert William (1856-1944). Representing Leland Stanford Jr. University, USA.

Struthers, Joseph (1865-1923). Private citizen from New York City, USA.

Waddell, John Alexander Low (1854-1938). Private citizen from Kansas City, MO, USA.

Wheeler, Homer Jay (1861-1938). Private citizen from Kingston, RI, USA.

Wiley, Harvey Washington (1844-1930). Representing the USDA, USA.

Department 19 - Economics

Adams, Henry Carter (1851-1921). Representing the University of Michigan, USA.

Clark, John Bates (1847-1938). Representing Columbia University, USA.

Cummings, John (1868-1936). Representing the University of Chicago, USA.

Fetter, Frank Albert (1863-1949). Representing Cornell University, USA.

Hoffman, Frederick Ludwig (1865-1946). Representing the Prudential Insurance Company, USA.

Hollander, Jacob Harry (1871-1940). Representing Johns Hopkins University, USA.

Johnson, Emory Richard (1864-1950). Representing the University of Pennsylvania, USA.

Jones, Edward David (1870-1944). Representing the University of Michigan, USA.

Laughlin, Lawrence (1850-1933). Representing the University of Chicago, USA.

McLintock, Emory (1840-1916). Representing the Mutual Life Insurance Company, USA.

Meyer, Balthasar Henry (1866-1954). Representing the University of Wisconsin, USA.

Miller, Adolph Casper (1866-1953). Representing the University of California, USA.

von Philippovich, Eugene (1858-1917). Representing the University of Vienna, Austria.

Plehn, Carl Copping (1867-1945). Representing the University of California, USA.

Pope, Jesse Eliphalet (1869-1962). Representing the University of Missouri, USA.

Ripley, William Zebina (1867-1941). Representing Harvard University, USA.

Seligman, Edwin Robert Anderson (1861-1939). Representing Columbia University, USA.

Tunell, George Gerard (Sr) (1867-1942). Private citizen from Chicago, Illinois, USA.

Walker, Byron Edmund (1848-1924). Representing the Canadian Bank of Commerce, Canada.

Division F – Social Regulation

Department 20 - Politics

Addams, Jane (1860-1935). Representing the Hull House, USA.

Andrews, Elisha Benjamin (1844-1917). Representing the University of Nebraska, USA.

Bryce, James (1838-1922). Nobleman and politician, representing Great Britain.

Dunning, William Archibald (1857-1922). Representing Columbia University, USA.

Fairlie, John Archibald (1872-1947). Representing the University of Michigan, USA.

Foster, John Watson (1836-1917). Former Secretary of State, USA.

Hill, David Jayne (1850-1932). Minister of the United States to Switzerland, USA.

Judson, Harry Pratt (1849-1927). Representing the University of Chicago, USA.

Moses, Bernard Norton (1846-1930). Representing the University of California, USA.

Reinsch, Paul Samuel (1869-1923). Representing the University of Wisconsin, USA.

Shaw, Albert (1857-1947). Representing the American Monthly Review, USA.

Willoughby, Westel Woodbury (1867-1945). Representing Johns Hopkins University, USA.

Wilson, George Grafton (1863-1951). Representing Brown University, USA.

Department 21 - Jurisprudence

Ames, James Barr (1846-1910). Representing Harvard University, USA.

Apponyi, Albert (1846-1933). Nobleman and politician, representing Hungary.

Beale, Joseph Henry (1861-1942). Representing Harvard University, USA.

Brunialti, Attilio (1849-1920). Nobleman and politician, representing Italy.

Burgess, John W. (1844-1931). Representing Columbia University, USA.

Dennis, William C. (birth and death unknown). Representing Leland Stanford Jr. University, USA.

Freund, Ernst (1864-1932). Representing the University of Chicago, USA.

Gregory, Charles Noble (1851-1932). Representing the University of Iowa, USA.

Kirchwey, George Washington (1855-1942). Representing Columbia University, USA.

La Fontaine, Henri (1854-1943). Politician representing Belgium.

Larnaude, Ferdinand (1853-1942). Representing the University of Paris, France.

Lewis, William Draper (1867-1949). Representing the University of Pennsylvania, USA.

Needham, Charles Willis (1848-1935). Representing Columbian University (Washington), USA.

Scott, James Brown (1866-1943). Representing Columbia University, USA.

Tucker, Henry St. George (III) (1853-1932). Representing George Washington University, USA.

Whitney, Edward Baldwin (1857-1911). Private citizen from New York City, New York, USA.

Department 22 – Social Science

Adams, Thomas Sewall (1873-1933). Representing Madison, WI, USA.

Adler, Felix (1851-1933). Representing Columbia University, USA.

Butterfield, Kenyon Leech (1868-1936). Representing the Rhode Island State Agricultural College, USA.

DeForest, Robert Weeks (1848-1931). Representing New York City, USA.

Dike, Samuel Warren (1839-1913). Representing Auburndale, Massachusetts, USA.

Ely, Richard Theodore (1854-1943). Representing University of Wisconsin, USA.

Henderson, Charles Richmond (1848-1915). Representing the University of Chicago, USA.

Hill, William (b. and d. unknown). Representing the University of Chicago, USA.

Howard, George Elliott (1849-1928). Representing the University of Nebraska, USA.

Jastrow, Ignaz (1856-1937). Representing the University of Berlin, Germany.

Jones, Aaron (b. and d. unknown). Representing the National Grange, South Bend, Indiana, USA.

Münsterberg, Emil (1855-1911). Representing the German Association for Poor Relief, Germany.

Sheldon, Walter L. (1858-1905). Representing the Ethical Society, St. Louis, USA.

Smith, Samuel George (1852-1915). Representing the University of Minnesota, USA.

Sombart, Werner (1863-1941). Representing the University of Breslau, Germany.

Taylor, Graham (1851-1938). Representing the Chicago Theological Seminary, USA.

Weber, Max (1864-1920). Representing the University of Heidelberg, Germany.

Wines, Frederick Howard (1838-1912). Representing the State Charities Aid Association, New Jersey, USA.

Wuarin, Louis (1846-1927). Representing the University of Geneva, Switzerland.

Division G – Social Culture

Department 23 - Education

Axon, William Edward Armytage (1846-1913). Private citizen from Manchester, Great Britain.

Biagi, Guido (1855-1925). Royal Librarian, representing Italy.

Brown, Elmer (1861-1934). Representing the University of California, USA.

Carey Thomas, Martha (1857-1935). Representing Bryn Mawr College, USA.

Chabot, Charles (1857-1924). Representing the University of Lyon, France.

Chaplin, Winfield Scott (1847-1918). Representing Washington University, USA.

Crunden, Frederick Morgan (1847-1911). Representing the St. Louis Public Library, USA.

DeGarmo, Charles (1849-1934). Representing Cornell University, USA.

Hadley, Arthur Twining (1856-1930). Representing Yale University, USA.

Horne, Herman Harrell (1874-1946). Representing Dartmouth College, USA.

Hyde, William De Witt (1858-1917). Representing Bowdoin College, USA.

King, Henry Churchill (1858-1934). Representing Oberlin College, USA.

Langsdorf, Alesander Suss (1877-1973). Representing Washington University, USA.

Maxwell, William Henry (1852-1920). Superintendent of Public Schools, New York City, USA.

Peabody, Francis Greenwood (1847-1936). Representing Harvard University, USA.

Perry, Edward Delavan (1854-1938). Representing Columbia University, USA.

Pettus, Charles Parsons (1877-1923). Representing Washington University, USA.

Rein, Wilhelm (1847-1929). Representing the University of Jena, Germany.

Sadler, Michael Ernest (Sir) (1861-1943). Representing the University of Manchester, Great Britain.

Soldan, Frank Louis (1842-1908). Superintendent of Public Schools, St. Louis, USA.

Spalding, John Lancaster (1840-1916). Bishop of Peoria, USA.

Vincent, John Heyl (1832-1920). Representing New York, USA.

Whipple, Guy Montrose (1876-1941). Representing Cornell University, USA.

Wilson, Thomas Woodrow (1856-1924). Representing Princeton University, USA.

Woodward, Robert Simpson (1849-1924). Representing Columbia University, USA.

Department 24 – Religion

Black, Hugh (1868-1953). Private citizen from Edinburgh, Scotland.

Buckley, James Monroe (1836-1920). Representing the Christian Advocate, USA.

Coe, George Albert (1862-1951). Representing Northwestern University, USA.

Eliot, Samuel Atkins (1862-1950). Private citizen from Boston, Massachusetts, USA.

Gailor, Thomas Frank (1856-1935). Private citizen from Memphis, Tennessee, USA.

Garrison, James Harvey (1842-1931). Private citizen from St. Louis, Missouri, USA.

Gladden, Washington (1836-1918). Private citizen from Columbus, Ohio, USA.

Hall, Charles Cuthbert (1872-1962). Representing the Union Theological Seminary, USA.

Hervey, Walter Lowrie (1862-1952). Representing the Board of Education, New York City, USA.

Hirsch, Emil Gustav (1851-1923). Private citizen from Chicago, Illinois, USA.

Kirkland, James Hampton (1859-1939). Representing Vanderbilt University, USA.

Landrith, Ira (1865-1941). Representing the Religious Education Society, USA.

Mabie, Henry Clay (1847-1918). the Representing American Baptist Missionary Union, USA.

McFadyen, John Edgar (1870-1933). Representing Knox College, Canada.

Moore, Edward C. (1857-1943). Representing Harvard University, USA.

Mullins, Edgar Young (1860-1928). Representing the Southern Baptist Theological Seminary, USA.

Pollard, Edward B. (1864-1927). Private citizen from Georgetown, Kentucky, USA.

Sanders, Frank Knight (1861-1933). Representing Yale University, USA.

Starbuck, Edwin Diller (1866-1947). Representing Earlham College, Indiana, USA.

Strong, Josiah (1847-1916). Representing the League for Social Service, NY, USA.

Swain, Joseph (1857-1927). Representing Swarthmore College, USA.

Tomkins, Floyd Williams (1850-1932). Private citizen from Philadelphia, PA, USA.

Votaw, Clyde W. (1864-1946). Representing the University of Chicago, USA.

Willett, Herbert Lockwood (1864-1944). Representing the Disciples Divinity House, Chicago, USA.

APPENDIX B

Social Framework for the Early Ecology Network

This study has focused on the social and professional connections of ecological thinkers who attended the International Congress of Arts and Science. Ecological thinking was found within the biology, geography, history, and anthropology departments (see Appendix A for a list). Data was compiled regarding the social and political relationships of the participants in these departments, in some cases including colleagues, employers, spouses, and mentors. The aggregate constitutes a framework for the early ecology network. The diagram below shows these interconnections at a high level. The figure demonstrates that the network was dense, i.e. most individuals had multiple connections. Heat mapping is applied; red and orange edges show centralized clusters. To see a detailed version that shows labels for nodes and edges, please view the diagram on page 183.

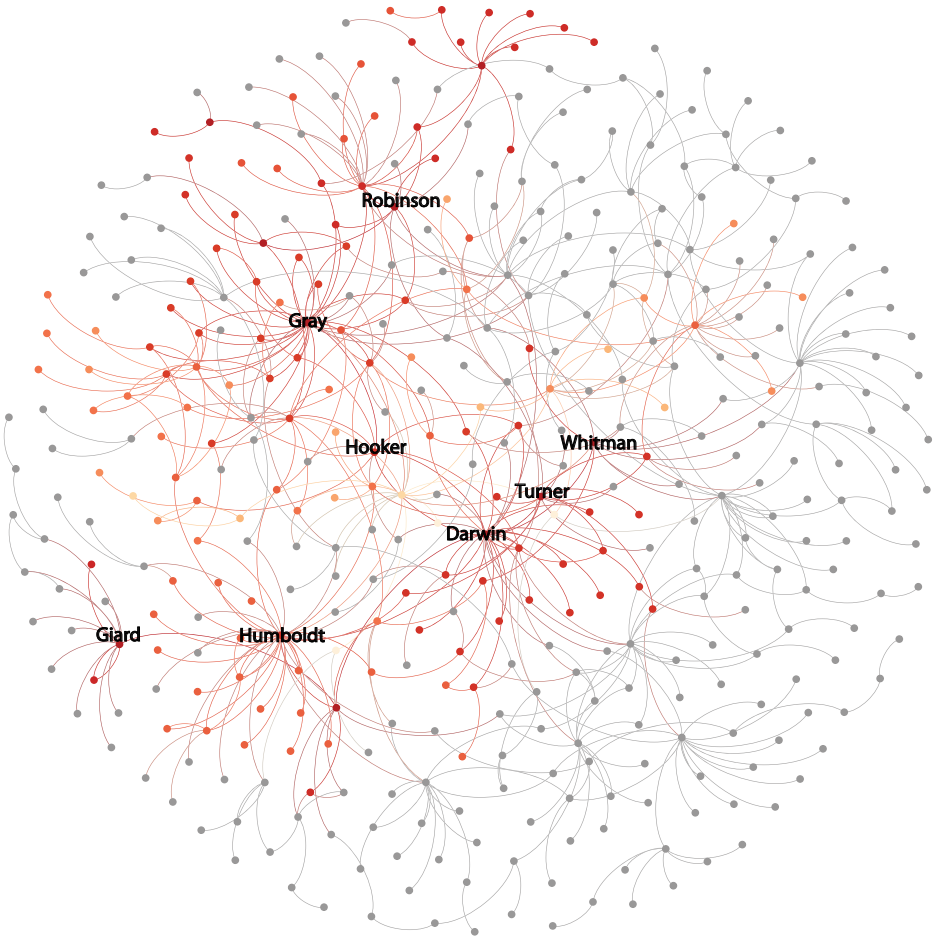

Figure B.1 Subset of the early ecology network, showing density. Major figures discussed in the dissertation are labeled.

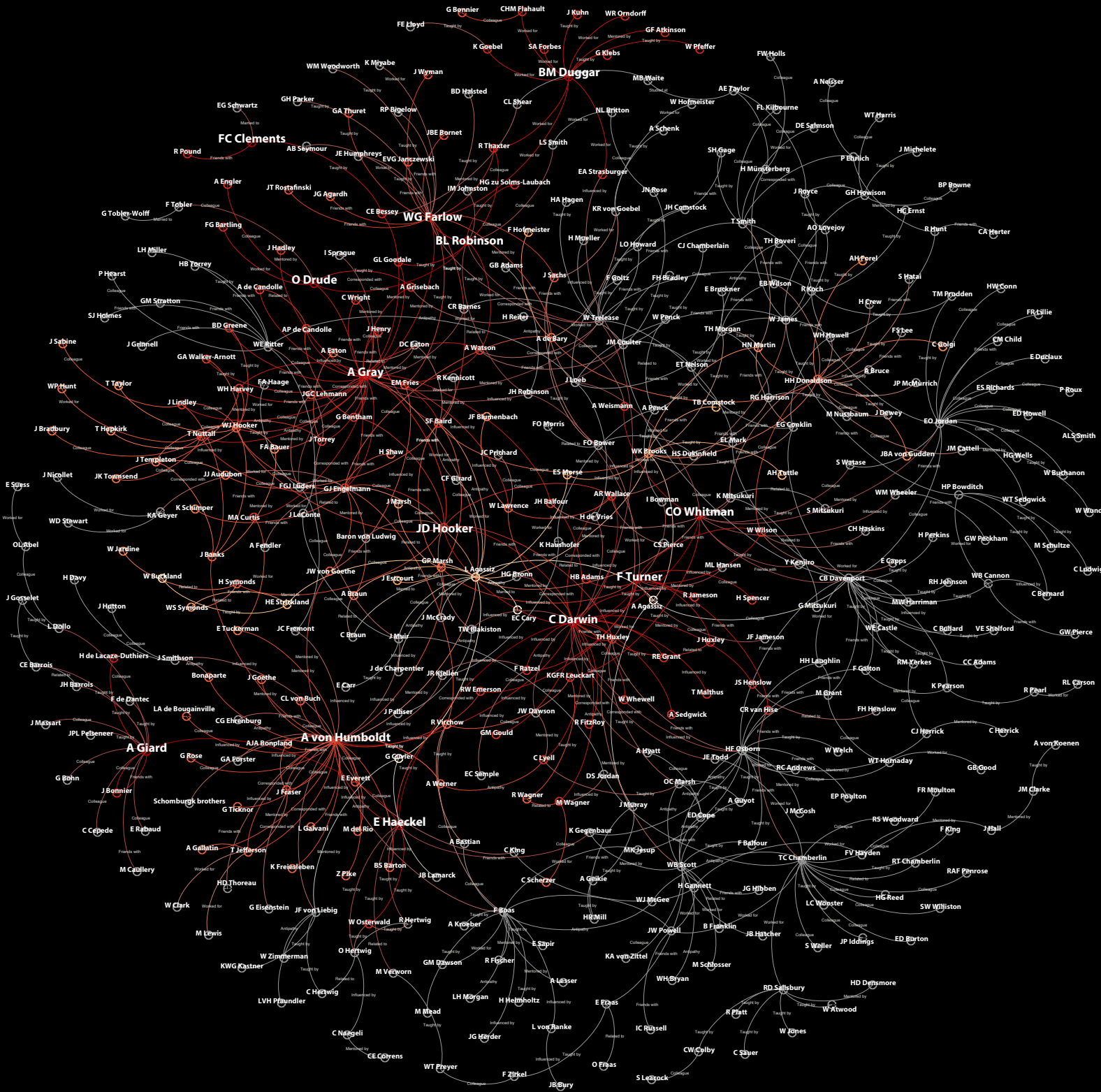

Figure B.2 Subset of the early ecology network within its social framework. Best viewed in Adobe Acrobat (use zoom function).

The following individuals were connected to the early ecology network either socially or professionally, but were *not* participants in the International Congress of Arts:

Abel, Othenio Lothar (1875-1946). Austrian founder of palaeobiology.

Adams, Charles Christopher (1873-1955). American zoologist and ecologist.

Adams, George Burton (1851-1925). American historian.

Adams, Herbert Baxter (1850-1901). American historian.

Agardh, Jacob Georg (1813-1901). Swedish botanist.

Agassiz, Alexander (1835-1910). American marine biologist.

Agassiz, Cecile (nee. Braun) (1809-1848). Sister of Alexander Braun, married to Louis Agassiz.

Agassiz, Louis (1807-1873). Swiss-American biologist and geologist, anti-Darwinist.

Andrews, Roy Chapman (1884-1960). American explorer and naturalist, director of the American Museum of Natural History.

Atkinson, George Francis (1854-1918). American cryptogamic botanist.

Atwood, Wallace Walter (1872-1949). American geologist, president of Clark University.

Audubon, John James (1785-1851). French-American ornithologist and artist.

Baird, Spencer Fullerton (1823-1887). American naturalist, curator of Smithsonian Institution.

Balfour, Francis Maitland (1851-1882). British evolutionary embryologist.

Balfour, John Hutton (1808-1884). Scottish botanist, professor at University of Edinburgh and Regius Keeper of the Royal Botanic Garden.

Banks, Joseph (Sir) (1743-1820). British naturalist, President of the Royal Society.

Barrois, Charles Eugene (1851-1939). French geologist, professor at the University of Lille.

Barrois, Jules Henri (1852-1943). French zoologist, Head of the Observatoire Océanologique de Villefranche at Villefranche-sur-Mer.

Bartling, Friedrich Gottlieb (1798-1875). German botanist, professor at Göttingen.

Barton, Benjamin Smith (1766-1815). American botanist and physician.

de Bary, Heinrich Anton (1831-1888). German surgeon and botanist, established plant pathology.

Bastian, Adolf (1826-1905). German anthropologist, founder and Director of the Ethnological Museum of Berlin.

Bauer, Franz Andreas (1758-1840). Moravian microscopist and botanical artist.

Bebb, Michael Schuck (1833-1895). American botanist and politician.

Bentham, George (1800-1884). English botanist.

Bernard, Claude (1813-1878). French physiologist and playwright.

Bingham, Caroline Priscilla (1831-1932). American botanist.

Blakiston, Thomas Wright (1832-1891). British ornithological collector and soldier.

Blumenbach, Johann Friedrich (1752-1840). German naturalist and anthropologist.

Bohn, Georges (1868-1948). French zoologist.

Bonaparte, Napoléon (1769-1821). French military and political leader.

Bonnier, Gaston (1853-1922). French plant ecologist, professor at the Sorbonne.

Bonnier, Jules (1859-1908). French zoologist.

Bonpland, Aimé Jacques Alexandre (1773-1858). French botanist.

Bornet, Jean-Baptiste Édouard (1828-1911). French botanist, lichen specialist.

de Bougainville, Louis (1729-1811). French admiral and explorer.

Braun, Alexander Carl Heinrich (1805-1877). German plant morphologist.

Britton, Nathaniel Lord (1859-1934). American botanist and taxonomist, founder of the New York Botanical Garden.

Bronn, Heinrich Georg (1800-1862). German palaeontologist.

Bruce, William Speirs (1867-1921). Scottish oceanographer, founder of Edinburgh Zoo, and founder of a marine laboratory in Edinburgh.

von Buch, Christian Leopold (1774-1853). German geologist and paelontologist.

Buckland, William (1784-1856). English geologist and theologian.

Burrill, Thomas Jonathan (1839-1916). American botanist who focused on plant disease.

de Candolle, Alphonse Louis Pierre Pyrame (1806-1893). Swiss botanist.

de Candolle, Augustin Pyramus (1778-1841). Swiss botanist.

Cannon, Walter (1871-1945). American physiologist, coined the expression “flight or fight” response.

Carson, Rachel Louise (1907-1964). American aquatic biologist and conservationist.

Castle, William Ernest (1867-1962). American geneticist.

Caullery, Maurice (1868-1958). French zoologist.

Cépède, Casimir (1882-1954). French zoologist.

Chamberlain, Charles Joseph (1863-1943). American botanist.

Chamberlin, Rollin Thomas (1881-1948). American chemist and geologist.

de Charpentier, Jean (1786-1855). German-Swiss geographer, specialist in glaciology.

Child, Charles Manning (1869-1954). American zoologist.

Clements, Edith (née Schwartz) (1874-1971). American botanist and ecologist.

Comstock, John Henry (1849-1931). American entomologist.

Conklin, Edwin Grant (1863-1952). American zoologist.

Cook, George Hammell (1818-1889). American geologist and university administrator.

Cope, Edward Drinker (1840-1897). American palaeontologist, founder of neo-Lamarckism.

Curtis, Moses Ashley (1808-1872). American botanist and clergyman.

Cuvier, Jean Léopold Nicolas Frédéric (Georges) (1769-1832). French naturalist, provided the foundation of vertebrate palaeontology.

Dall, William Healey (1845-1927). American naturalist.

le Dantec, Félix-Alexandre (1869-1917). French biologist, specialist in cellular biology.

Darwin, Charles (1809-1892). English naturalist, proposed evolution by natural selection.

Dawson, George Mercer (1849-1901). Canadian geologist and surveyor.

Dewey, John (1859-1952). American educationalist.

Dollo, Louis Antoine Marie Joseph (1857-1931). French-born Belgian palaeontologist.

Driesch, Hans Adolf Eduard (1867-1914). German embryologist and neo-vitalist.

Duclaux, Émile (1840-1904). French microbiologist and chemist.

Dukinfield, Henry Scott (1854-1934). British botanist with Kew Gardens.

Eaton, Amos (1776-1842). American botanist, geologist, and college administrator.

Eaton, Daniel Cady (1834-1895). American botanist.

Ehrenburg, Christian Gottfried (1795-1876). German biologist and geologist.

Emerson, Ralph Waldo (1803-1882). American writer, lecturer, and philosopher.

Engelmann, Georg (1809-1884). German botanist, mentored by Johann von Goethe.

Engler, Adolf (1844-1930). German botanist, created system for plant classification.

Fendler, Augustus (1813-1883). German-American professional natural history collector.

Fischer,Theobald (1846-1910). German geographer, also trained in history.

Flahault, Charles Henri Marie (1852-1935). French botanist, pioneer of phytogeography, phytosociology, and forest ecology.

Forbes, Stephen Alfred (1844-1930). American aquatic biologist and ecologist.

Forel, Auguste-Henri (1848-1931). Swiss entomologist.

Forster, Georg Adam (1754-1794). German naturalist.

Fraser, John (1750-1811). Scottish botanist and nurseryman.

Freiesleben, Johann Carl (1774-1846). German geologist.

Fries, Elias Magnus (1794-1878). Swedish mycologist and botanist.

Gegenbaur, Karl (1826-1903). German comparative anatomist.

Geikie, Archibald (Sir) (1835-1924). Scottish geologist.

Geyer, Karl Andreas (1809-1853). German botanist and nurseryman.

Gilman, Daniel Coit (1831-1908). American college administrator.

Girard, Charles Frederic (1822-1895). French-American ichthyologist and herpetologist.

von Goebel, Karl Ritter (1855-1932). German morphologist.

von Goethe, Johann Wolfgang (1749-1832). German philosopher and politician.

Goode, George Brown (1851-1896). American ichthyologist and museum administrator.

Goodale, George Lincoln (1839-1923). American botanist, herbarium administrator.

Gosselet, Jules (1832-1916). French geologist.

Gould, John (1804-1991). British ornithologist.

Grant, Madison (1865-1937). American lawyer, eugenicist and conservationist.

Grant, Robert Edmund (1793-1874). Scottish zoologist, focused on marine biology.

Gray, Asa (1810-1888). American botanist, herbarium administrator.

Greene, Benjamin Daniel (1793-1862). American botanist and administrator.

Grisebach, August (1814-1879). German botanist and phytogeographer.

Guyot, Arnold Henry (1807-1884). Swiss-American geologist and geographer.

Haeckel, Ernst (1834-1919). German biologist.

Hagen, Hermann August (1817-1893). German-American entomologist.

Hall, James (Jr) (1811-1898). American palaeontologist.

Hallez, Paul (1846-1938). French zoologist and embryologist.

Halsted, Byron David (1852-1918). American botanist and plant pathologist.

Hansen, Marcus Lee (1892-1938). American historian known for migration studies.

Harrison, Ross Granville (1870-1959). American biologist and anatomist.

Harvey, William Henry (1811-1866). Irish botanist and phycologist.

Hatai, Shinkishi (1876-1963). Japanese botanist and marine biologist.

Hayden, Ferdinand Vandeveer (1829-1887). American geologist and surveyor.

von Helmholtz, Hermann Ludwig Ferdinand (1921-1894). German physician, physicist, and philosopher of science.

Henle, Friedrich Gustav Jakob (1809-1885). German physician, pathologist, and anatomist.

Henry, Joseph (1797-1878). American scientist, first Secretary of the Smithsonian Institution.

Henslow, John Stevens (1796-1861). British priest, botanist and geologist who taught Charles Darwin.

Herrick, Charles Judson (1868-1960). American biologist.

Herter, Christian Archibald (1865-1910). American physician and pathologist.

Hertwig, Richard (1850-1937). German zoologist and embryologist.

Hildebrandt, Johann Maria (1847-1881). German geographer.

Hofmeister, Franz (1850-1922). German protein scientist.

Hofmeister, Wilhelm (1824-1877). German botanist.

Holls, Frederick William (1857-1903). American lawyer.

Holmes, Samuel Jackson (1868-1964). American zoologist and eugenicist.

von Holst, Hermann Eduard (1841-1904). German-American historian.

Hooker, Frances Harriet (née Henslow) (1825-1874). British gentlewoman, daughter of John Steven Henslow and wife of Joseph Dalton Hooker.

Hooker, Joseph Dalton (1817-1911). British botanist, Director of Kew Gardens.

Hooker, William Jackson (1785-1865). British botanist, professor at Glasgow University, Director of Kew Gardens.

Hopkirk, Thomas (1749-1841). Scottish botanist and lithographer.

Hornaday, William Temple (1854-1937). American zoologist and conservationist.

von Humboldt, Alexander (1769-1859). German geographer and naturalist.

Hunt, William Price (1783-1842). American trader and explorer.

Hutton, James (1726-1797). Scottish geologist and chemical manufacturer.

Huxley, Julian (1887-1975). British evolutionary biologist and eugenicist.

Huxley, Thomas Henry (1825-1895). British comparative anatomist.

Hyatt, Alpheus (1838-1902). American zoologist and palaeontologist.

Iddings, Joseph P. (1857-192). American geologist.

Jacobi, Carl Wigand Maximilian (1775-1858). German psychiatrist.

James, Edmund (1855-1925). American economist, President of the University of Illinois.

James, William (1842-191). American philosopher and psychologist.

Jameson, John Franklin (1859-1937). American historian.

Jameson, Robert (1774-1854). Scottish mineralogist.

Janczewski, Eduard von Glinka (1846-1918). Polish botanist.

Jefferson, Thomas (1743-1826). American Founding Father, President, and naturalist.

Johnston, Ivan Murray (1898-1960). American botanist.

Kennicott, Robert (1835-1866). American herpetologist.

King, Clarence Rivers (1842-1901). American geologist.

Kjellén, Johann Rudolf (1864-1922). Swedish political scientist, coined the term «geopolitics.»

Klebs, Georg (1857-1918). German botanist.

Koch, Robert (1843-1910). German physician and microbiologist.

von Koenen, Adolf (1837-1915). German geologist and paleontologist.

Kuhn, Julius Gotthelf (1825-1910). German plant pathologist.

de Lacaze-Duthiers, Félix Joseph Henri (1821-1901). French marine biologist.

Lamarck, Jean-Baptiste (1744-1829). French naturalist.

Laughlin, Harry Hamilton (1880-1943). American eugenicist.

Lawrence, William (1783-1867). British physician.

Leclerc, George-Louis (Comte de Buffon) (1707-1788). French naturalist and mathematician.

Lehmann, John Georg Christian (1792-1860). German botanist.

Leuckart, Rudolf (1822-1898). German zoologist.

Lewis, Meriwether (1774-1809). American soldier and explorer.

von Liebig, Justus Freiherr (1803-1873). German chemist.

Lindley, John (1799-1865). British botanist.

von Linné, Carl (Linneaus) (1707-1778). Swedish botanist and physician who formalized binomial nomenclature.

Logan, William Edmund (1798-1875). Canadian geologist.

Lotze, Hermann (1817-1881). German philosopher, trained in biology.

Lüders, Friedrich (1813-1904). German-American naturalist.

von Ludwig, Carl (1784-1847). German pharmacist, founded Cape Town's botanic garden.

Ludwig, Carl (1816-1895). German comparative anatomist.

Lyell, Charles (1797-1875). British lawyer and geologist.

Malthus, Thomas Robert (1766-1834). British cleric and political economist.

Mark, Edward Laurens (1847-1946). American zoologist.

Marsh, George Perkins (1801-1882). American diplomat, philologist, and conservationist.

Marsh, Othniel Charles (1831-1899). American palaeontologist.

Martin, Henry Newell (1848-1896). British physiologist.

Massart, Jean (1865-1925). Belgian botanist.

Matthew, William Diller (1871-1930). Canadian-American vertebrate palaeontologist.

McCosh, James (1811-1894). Scottish-American philosopher and college administrator.

McCrady, John (1831-1881). American zoologist.

Mendenhall, Thomas Corwin (1841-1924). American physicist and meteorologist.

Miyabe, Kingo (1860-1950). Japanese botanist.

Morse, Edward Sylvester (1838-1925). American zoologist.

Muller, Hermann Joseph (1890-1967). American geneticist.

Muir, John (1838-1914). Scottish-American naturalist and philosopher.

Nuttall, Thomas (1786-1859). British biologist who worked in the United States.

Orndorff, William Ridgeley (1862-1927). American organic chemist.

Parker, George Howard (1864-1955). American zoologist.

Pearl, Raymond (1879-1940). American biologist, founder of biogerontology.

Pearson, Karl (1857-1936). British biostatistician.

Peck, William Dandridge (1763-1822). American botanist and entomologist.

Peirce, Charles Sanders (1839-1914). American philosopher and scientist.

Penck, Walther (1888-1923). German geomorphologist.

Pfeffer, Wilhelm.(1845-1920). German plant physiologist.

Phelps, Susanna Stuart (1857-1915). American comparative anatomist.

Poulton, Edward Bagnell (1856-1943). British evolutionary biologist.

Pound, Roscoe (1870-1964). American legal scholar who studied botany under Charles Bessey.

Powell, John Wesley (1834-1902). American soldier and geologist.

Preyer, William Thierry (1841-1897). British chemist and physiologist.

Pritchard, James Cowles (1786-1848). British physician and ethnologist.

Prudden, Theophil Mitchell (1849-1924). American pathologist.

Rabaud, Étienne (1868-1956). French zoologist.

von Ranke, Leopold (1795-1886). German historian.

Ratzel, Friedrich (1844-1904). German geographer.

Reichert, Karl Bogislaus (1811-1883). German embryologist, pioneer researcher on cell theory.

Reiter, Hanns (1859-d. unknown). German biologist, one of the first to use the term ecology.

Richards, Ellen Swallow (1842-1911). American industrial and environmental chemist.

del Rio, Manuel (1764-1849). Spanish-Mexican geologist.

Ritter, Carl (1779-1859). German naturalist, one of the founders of geography.

Rose, Gustav (1798-1873). German mineralogist.

Rose, Joseph Nelson (1862-1928). American botanist and palaeobotanist.

Rostafinski, Josef Thomas (1850-1928). Polish botanist.

Rousseau, Jean-Jacques (1712-1778). French philosopher.

Roux, Pierre (1853-1933). French physician and bacteriologist.

von Sachs, Julius (1832-1897). German botanist.

Schenk, August (1815-1891). Austrian botanist and palaeobotanist, professor at the University of Liepzig.

von Scherzer, Karl (1821-1903). Austrian naturalist and explorer.

Schimper, Andreas Franz Wilhelm (1856-1901). German botanist.

Schimper, Karl Friedrich (1803-1867). German botanist, trained in theology and plant morphology.

Schlosser, Max (1854-1932). German zoologist and palaeontologist.

Schomburgk, Richard (1811-1891). German botanist, herbarium adminitrator.

Schomburgk, Robert Hermann (1804-1865). German-born explorer for Britain.

Schultze, Max (1825-1874). German microscopic anatomist.

Sedgwick, Adam (1785-1873). British theologian and scientist, founder of geology.

Semple, Ellen Churchill (1863-1932). American geographer.

Seymour, Arthur Bliss (1859-1933). American botanist.

Seymour, Charles (1885-1963). American historian, college administrator.

von Seysenegg, Gustav Tschermak (1836-1927). Austrian mineralogist.

Shaw, Henry (1800-1889). British-American philanthropist, founder of the Missouri Botanical Garden.

Smithson, James (1765-1829). British chemist, founding donor of the Smithsonian Institution.

Spillman, William Jasper (1863-1931). American biologist, founder of agricultural economics.

zu Solms-Laubach, Hermann Graf (1842-1915). German botanist.

Sprague, Isaac (1811-1895). American botanical illustrator.

Strasburger, Eduard Adolf (1844-1912). Polish-German botanist.

Suess, Eduard (1831-1914). Austrian geologist.

Symonds, Hyacinth (1842-1921). British gentlewoman, daughter of William Samuel Symonds and wife of Joseph Dalton Hooker.

Symonds, William Samuel (1818-1887). British geologist.

Templeton, John (1766-1825). Irish botanist.

Thoreau, Henry David (1817-1862). American writer and naturalist, Transcendentalist.

Thuret, Gustav Adolphe (1817-1875). French botanist, founder of the Jardin botanique de la Villa Thuret.

Ticknor, George (1791-1871). American hispanist.

Tobler, Friedrich (1879-1957). German botanist, herbarium administrator.

Todd, James Edward (1846-1922). American theologian and geologist.

Torrey, John (1796-1873). American botanist, chemist, and physician.

Townsend, John Kirk (1809-1851). American ornithologist.

von Tschermak, Erich (1871-1962). Austrian agronomist.

Virchow, Rudolf (1821-1902). German scientist and politician.

Wagner, Moritz (1813-1887). German geographer and collector.

Walker-Arnott, George Arnott (1799-1868). Scottish botanist.

Wallace, Alfred Russel (1823-1913). British naturalist and biogeographer.

Ward, Henry Augustus (1834-1906). American geologist.

Warming, Eugen (1841-1924). Danish botanist and ecologist.

Watson, Sereno (1826-1892). American botanist.

Weismann, August (1834-1914). German evolutionary biologist.

Welch, William (1850-1934). American pathologist and college administrator.

Werner, Abraham Gottlob (1749-1817). German geologist.

Wheeler, William Morton (1865-1937). American entomologist.

Whitman, Walt (1819-1892). American writer and philosopher.

Wilder, Burt Green (1841-1925). American comparative anatomist.

Wordsworth, William (1770-1850). English poet.

Wright, Charles (1811-1885). American botanist.

Wundt, Wilhelm (1832-1920). German physiologist and psychologist.

Wyman, Jeffries (1814-1874). American naturalist and anatomist.

von Zittel, Karl Alfred (1839-1904). German palaeontologist.

BIBLIOGRAPHY

Primary Sources

Archives Consulted

Bodleian Library, Oxford University, UK

British Library, London, UK

Glasgow University Archives, Glasgow, UK

London Metropolitan Archives, London, UK

National Archives, Kew, UK

National Archives of Scotland, Edinburgh, UK

Royal Geographical Society Archives, London, UK

University of London Archives, London, UK

Archival Sources

Arthur Smith Woodward Papers, correspondence (DF 166/13). The Natural History Museum, London, UK.

Foreign Office, General Correspondence from Political and Other Departments before 1906, United States of America, Series II (1903). The National Archives at Kew, UK.

The Hugh Robert Mill Collection. RGS-IBS Collections (Archives Store N02). Royal Geographical Society Archives, London, UK.

Papers of Frederick Orpen Bower, 1855-1948, botanist (GB 248 DC 002). Glasgow University Archive Services, Glasgow, UK.

Proceedings of the International Congress of Arts and Science, St. Louis, 1904

International Congress of Arts and Science, 13 vols. Ed. Howard Jason Rogers. London and New York, University Alliance, 1908.

Papers from from the *Proceedings:*

Barnes, Charles R. "Plant Physiology." Vol 9, 101-2.

Boas, Franz. "The History of Anthropology." Vol 10, 468-82.

Bower, Frederick Orpen. "Plant Morphology." Vol 9, 61-80.

Brooks, William Keith. "Individual Development and Ancestral Development." Vol 9, 308-19.

Chamberlin, Thomas Chrowder. “The Methods of the Earth Sciences.” Vol 8, 477-87.

Coulter, John Merle. “Development of Morphological Conceptions.” Vol 9, 4-12.

Davenport, Charles Benedict. “Animal Morphology in Relation to Other Sciences.” Vol 9, 244-257.

Davies, William Morris. “The Relations of the Earth Sciences in View of the Progress in the Nineteenth Century.” Vol 8, 488-503.

de Vries, Hugo. “A Comparison between Artificial and Natural Selection.” Vol 9, 28-40.

Dennis, Frederic Shepard. “The History and Development of Surgery During the Past Century.” Vol 11, 307-80.

Drude, Oscar. “The Position of Ecology in Modern Science.” Vol 9, 177-90.

Erdmann, Benno. “The Content and Validity of the Causal Law.” Vol 1, 353-88.

Giard, Alfred Mathieu. “The Present Tendencies of Morphology and Its Relations to the Other Sciences.” Vol 9, 258-82.

Goebel, Karl F. “The Fundamental Problems of Present-Day Plant Morphology.” Vol 9, 81-98.

Lamprecht, Karl Gotthart. “Historical Development and Present Character of the Science of History.” Vol 3, 111-24.

Loeb, Jacques. “The Recent Development of Biology.” Vol 9, 13-24.

Mill, Hugh Robert. “The Present Problems of Geography.” Vol 8, 653-70.

Morgan, Thomas Hunt. “Phylogeny.” Vol 9, 27-8.

Newcomb, Simon. “The Evolution of the Scientific Investigator.” Vol 1, 135-47.

Münsterberg, Hugo. “The Scientific Plan of the Congress.” Vol 1, 85-134.

Osborn, Henry Fairfeld.“The Present Problems of Palaeontology.” Vol 8, 566-85.

Penck, Albrecht. “The Relations of Physiography to the Other Sciences.” Vol 8, 607-26.

Robinson, Benjamin Lincoln. “The Problems of Ecology.” Vol 9, 191-203.

Robinson, James Harvey. “The Conception and Methods of History.” Vol 3, 40-51.

Rogers, Howard Jason. “The History of the Congress.” Vol 1, 1-44.

Sloane, William Milligan. “The Science of History in the Nineteenth Century.” Vol 3, 23-39.

Turner, Frederick Jackson. “Problems in American History.” Vol 3, 183-94.

Whitman, Charles Otis. “The Problem of The Origin of Species.” Vol 9, 41-58.

Wiesner, Julius. “The Development of Plant Physiology under the Influence of the Other Sciences.” Vol 9, 103-24.

Wilson, Woodrow. “The Variety and Unity of History.” Vol 3, 3-20.

Woodward, Arthur Smith. “The Relations of Palaeontology to Other Branches of Science.” Vol 8, 551-565.

Additional Published Primary Sources

Agassiz, Louis. *Contributions to the Natural History of the United States of America*. Boston: Little, Brown and Co., 1857.

Board of Lady Managers of the Louisiana Purchase Exposition. *Report to the Louisiana Purchase Exposition Commission*. Cambridge, Mass.: The Riverside Press, 1905.

Bennitt, Mark. *History of the Louisiana Purchase Exposition*. St. Louis: Universal Exposition Publishing Company, 1905. Reprint, 1976.

Bessey, Charles E. *Botany for High Schools and Colleges*. New York: Henry Holt, 1880.

Blakiston, Thomas Wright. “Zoological Indications of Ancient Connection of the Japan Islands with the Continent.” *Miscellanea Ornithologica* Vol. 32, Tokyo: Asiatic Society of Japan, 1883.

Butler, Nicholas Murray, and Simon Newcomb. “Invitation to the International Congress of Arts and Science.” *Science* 20, no. 505 (1904), 317.

Clements, Frederic E. *Research Methods in Ecology*. Lincoln: University of Nebraska Press, 1905.

Darwin, Charles. *On the Origin of Species by Means of Natural Selection: Or, the Preservation of Favoured Races in the Struggle for Life*. London: John Murray, 1859.

Davis, William Harper. “The International Congress of Arts and Science.” *Popular Science Monthly* 66, no. November (1904): 5-32.

Gray, Asa. *Address of Professor Asa Gray: Ex-President of the Association*. Cambridge, Massachusetts: John Wilson and Son, 1873.

Mill, Hugh Robert. *Hugh Robert Mill: An Autobiograph*y. London: Longmans, Green & Co., 1951.

Prichard, James Cowles. *Researches into the Physical History of Mankind*. London: Sherwood, Gilbert, and Piper, 1836.

Prichard, James Cowles, and R. G. Latham. *The Eastern Origin of the Celtic Nations Proved by a Comparison of Their Dialects with the Sanskrit, Greek, Latin, and Teutonic Languages: Forming a Supplement to Researches into the Physical History of Mankind.* London: Houlston and Wright, 1857.

Schleiden, M. J. *Grundzüge Der Wissenschaftlichen Botanik Nebst Einer Methodologischen Einleitung Als Anleitung Zum Studium Der Pflanze* [in German]. Leipzig: W. Engelmann, 1842.

Turner, Frederick Jackson. "The Significance of the Frontier in American History." Paper presented at the American Historical Association Annual Meeting, World Columbian Exposition, Chicago, Illinois. Bobbs-Merrill Reprint Series in History, 1893.

Wallace, Alfred Russel. "On the Law which has Regulated the Introduction of New Species." *Annals and Magazine of Natural History 2nd Series* 16 (1855), 184-196.

Secondary Sources

Abrahamsson, Carl. On the Genealogy of Lebensraum." *Geographica Helvetica* 68 (2013): 47-44.

Allaby, Michael. *Ecology: Plants, Animals, and the Environment*. New York: Facts on File, 2010.

Allan, Mea. *The Hookers of Kew, 1785-1911*. London: Michael Joseph Ltd., 1967.

Allen, John Logan. *Passage through the Garden: Lewis and Clark and the Image of the American Northwest*. Illinois: University of Illinois, 1974.

Anonymous. "Dr. Benjamin D. Greene." *Anniversary Memoirs of the Boston Society of Natural History*. Boston: Boston Society of Natural History, 1880.

Archives of the Gray Herbarium, Harvard University Herbaria. *Papers of Benjamin Lincoln Robinson, 1887-1934: A Guide.* Massachusetts: Harvard University, 1999. Available online at: http://oasis.lib.harvard.edu/oasis/deliver/~gra00046

Ballard, Harlan Hoge. *Amos Eaton.* Pittsfield, Massachusetts: Sun Printing Company, 1897.

Baker, I.D.B. "C. G. Ehrenberg and W. F. Hemprich's Travels, 1820–1825, and the Insecta of the Symbolae Physicae." *Deutsche Entomologische Zeitschrift* 44, no 2 (1997):165–202.

Bamforth, Douglas. "An Empirical Perspective on the Little Ice Age: Climatic Change on the Great Plains." *Plains Anthropologist* 35 (1990): 359-66.

Barton, William P. C. *A Biographical Sketch Read Pursuant to Appointment before the Philadelphia Medical Society ... 16th February 1810 [Sic] of Their Late President Professor Barton*. Philadelphia: Philadelphia Medical Society, 1816.

Beaudoin, Alywnne. “What They Saw: The Climatic and Environmental Context for Euro-Canadian Settlement in Alberta.” *Prairie Forum* 24, no. 1 (1999): 1-40.

Bechtel, Stefan. *Mr. Hornaday’s War: How a Peculiar Victorian Zookeeper Waged a Lonely Crusade for Wildlife That Changed the World*. Boston: Beacon Press, 2012.

Bellon, R. “A Question of Merit: John Hutton Balfour, Joseph Hooker and the ‘Concussion’ over the Edinburgh Chair of Botany.” *Studies in History and Philosophy of Biological and Biomedical Sciences* 36, no. 1 (Mar 2005): 25-54.

Berry, Wendell. *Home Economics: Fourteen Essays*. San Francisco: North Point Press, 1987.

Betts, Richard A. “Self-Beneficial Effects of Vegetation on Climate in an Ocean-Atmosphere General Circulation Model.” *Geophysical Research Letters* 26, no. 10 (1999): 1457-60.

Bhopal, Raj. “The Beautiful Skull and Blumenbach’s Errors: The Birth of the Scientific Concept of Race.” *British Medical Journal* 335, no. 7633 (2007): 1308-09.

Billington, Ray Allen. “Why Some Historians Rarely Write History: A Case Study of Frederick Jackson Turner.” *The Mississippi Valley Historical Review* 50, no. 1 (1963): 3-27.

Blandin, Patrick. “Ecology: From a Crossroads Discipline Towards a Synthetic Science.” In *The European Origins of Scientific Ecology (1800-1901)*, ed. Pascal Acot. *Editions Des Archives Contemporaines*. Amsterdam: Gordon and Breach, 1998.

Bodansky, Daniel. “Prologue to the Climate Change Convention.” I*n Negotiating Climate Change: The Inside Story of the Rio Convention*, ed. Irving M. Mintzer and J. Amber Leonard. Cambridge, United Kingdom: Cambridge University Press, 1994.

Böger, Astrid. *Envisioning the Nation: The Early American World’s Fairs and the Formation of Culture*. Frankfurt: Campus, 2010.

“Bornet, Jean Baptiste Edouard”. *Encyclopædia Britannica* (12th edition), ed. Hugh Chisholm. UK: Cambridge University Press, 1922.

Botting, Douglas. *Humboldt and The Cosmos*. London: Michael Joseph, 1973.

Boulger, George Simonds. “Fraser, John (1750-1811)”. *Dictionary of National Biography* 20. Ed. Leslie Stephen. London: Smith, Elder & Co.,1889, 213–14.

Bowler, Peter J. *The Eclipse of Darwinism: Anti-Darwinian Evolution Theories in the Decades around 1900*. Baltimore: Johns Hopkins University Press, 1992.

———. *The Mendellian Revolution*. Baltimore: The Johns Hopkins University Press, 1989.

———. *Evolution, the History of an Idea*. Berkeley: University of California, 1984.

———. “Edward Drinker Cope and the Changing Structure of Evolutionary Theory.” *Isis* 68, no. 2 (1977): 249-65.

Bowler, Peter J., and Iwan Rhys Morus. *Making Modern Science: A Historical Survey*. Chicago: University of Chicago, 2005.

Boyer, John W. *"We Are All Islanders to Begin With:" The University of Chicago and the World in the Late Nineteenth and Twentieth Centuries*. Chicago: University of Chicago Press, 2008.

Bramwell, Anna. *Ecology in the 20th Century: A History*. New Haven: Yale University, 1989.

Brewer, William M. "The Historiography of Frederick Jackson Turner." *The Journal of Negro History* 44, no. 3 (1959): 240-59.

Brown, Julie K. *Health and Medicine on Display: International Expositions in the United States, 1876-1904*. Cambridge, Massachusetts: MIT Press, 2009.

Browne, E. J. *Charles Darwin: The Power of Place*. New York: A.A. Knopf, 2002.

Buchholz, J.T. "Charles Joseph Chamberlain." *Botanical Gazette* 104, no. 3 (1943): 369-70.

Burkhardt, Frederick. *Correspondence of Charles Darwin*. Cambridge, UK: Cambridge University Press, 1991.

Burkhardt, Richard W. (Jr). "Ethology, Natural History, the Life Sciences, and the Problem of Place." *Journal of the History of Biology* 32, no. 3 (1999): 489-508.

Carlson, Laurie M. *William J. Spillman and the Birth of Agricultural Economics*. Missouri: University of Missouri Press, 2005.

Carson, Rachel. *Silent Spring*. New York: Houghton Mifflin (Mariner Books ebook), 2002. First edition Riverside Press, 1962.

Caullery, Maurice. "Professor Alfred Giard (1846-1908)." *Science* 29, no. 732 (1909): 70-71.

Chalmers, John. *Audubon in Edinburgh*. Edinburgh: National Museums of Scotland Publishing, 2003.

Chalmers, William. *George Mercer Dawson: Geologist, Scientist, Explorer*. Montréal, XYZ Publishing, 2000.

Chambers, Neil, and Joseph Banks. *The Letters of Sir Joseph Banks: A Selection, 1768-1820* Singapore: World Scientific, 2000.

Cittadino, Eugene. *Nature as the Laboratory: Darwinian Plant Ecology in the German Empire, 1880-1900*. Cambridge, United Kingdom: Cambridge University Press, 1990.

Coats, A. W. "American Scholarship Comes of Age: The Louisiana Purchase Exposition 1904." *Journal of the History of Ideas* 22, no. 3 (1961): 404-17.

Cole, Douglas. *Franz Boas: The Early Years, 1858-1906*. Vancouver: Douglas & McIntyre, 1999.

Comstock, Anna Botsford. *The Comstocks of Cornell: John Henry Comstock and Anna Botsford*

Comstock. New York: Comstock Publishing Associates, 1953.

Cook, George M. "Neo-Lamarckian Experimentalism in America: Origins and Consequences." *The Quarterly Review of Biology* 74, no. 4 (1999): 417-37.

Cooper, Gregory John. *The Science of the Struggle for Existence: On the Foundations of Ecology*. Cambridge, United Kingdom: Cambridge University Press, 2003.

Costa, James T. "The Darwinian Revelation: Tracing the Origin and Evolution of an Idea." *BioScience* 59, no. 10 (2009): 886-94.

Coulter, John Merle. "Charles E. Bessey." *Science* 41, no. 1060 (1915): 599-600.

Crane, Diana. *Invisible Colleges: Diffusion of Knowledge in Scientific Communities*. Chicago: University of Chicago, 1988.

Creese, Mary R. S., and Thomas M. Creese. *American and British Women in Science, 1800-1900: A Survey of Their Contributions to Research*. Lanham, Maryland: Scarecrow Press, 1998.

Cressey, George B. "Wallace W. Atwood, 1872-1949." *Annals of the Association of American Geographers* 39, no. 4 (1949): 296-306.

Cronon, William. "Revisiting the Vanishing Frontier: The Legacy of Frederick Jackson Turner." *The Western Historical Quarterly* 18, no. 2 (1987): 157-76.

Cunningham, Raymond J. "The German Historical World of Herbert Baxter Adams: 1874-1876." *The Journal of American History* 68, no. 2 (1981): 261-75.

Darwin, John. *The Empire Project: The Rise and Fall of the British World-System, 1830-1970*. Cambridge, United Kingdom: Cambridge University Press, 2009.

De Bont, Raf. *Stations in the Field: A History of Place-Based Animal Research, 1870-1930*. Chicago: Chicago University Press, 2015.

———. "Organisms in Their Milieu: Alfred Giard, His Pupils, and Early Ethology, 1870-1930." *Isis* 101, no. 1 (2010): 1-27.

———. "Between the Laboratory and the Deep Blue Sea: Space Issues in the Marine Stations of Naples and Wimereux." *Social Studies of Science* 39, no. 2 (2009): 199-227.

De Chadarevian, Soraya. "Laboratory Science Versus Country-House Experiments: The Controversy between Julius Sachs and Charles Darwin." *The British Journal for the History of Science* 29, no. 1 (1996): 17-41.

Deane, Walter. "Michael Schuck Bebb." *Botanical Gazette* 21, no. 2 (1896): 53-66.

DeConde, Alexander. *This Affair of Louisiana*. New York: Scribner, 1976.

Deiss, William A. "Spencer F. Baird and His Collectors." *Journal of the Society for the Bibliography of Natural History* 9, no. 4 (1980): 635-45.

"del Río, Andrés Manuel." *Oxford Dictionary of Scientists*, UK: Oxford University Press, 2003. Originally published in print, 1999. Available online at: http://www.oxfordreference.com/view/10.1093/acref/9780192800862.001.0001/acref-9780192800862-e-371?rskey=Ni9MmK&result=370

Desmond, Adrian. "Redefining the X Axis: Professionals, Amateurs and the Making of Mid-Victorian Biology." *Journal of the History of Biology* 34, no. 1 (2001): 3-50.

———. "Robert E. Grant: The Social Predicament of a Pre-Darwinian Transmutationist." *Journal of the History of Biology* 17, No. 2. (1984), 189-223

DeTerra, Helmut. *Humboldt: The Life and Times of Alexander Von Humboldt, 1769-1859*. New York: A.A. Knopf, 1955. Translated from the German.

Dewey, John. *Democracy and Education: An Introduction to the Philosophy of Education*. New York: The Macmillan Company, 1916.

Dritschilo, William. "Rachel Carson and Mid-Twentieth Century Ecology." *Bulletin of the Ecological Society of America* 87, no. 4 (2006): 357-67.

Drouin, Jean-Marc. "Botanical Geography." In *The European Origins of Scientific Ecology (1800-1901)*, edited by Pascal Acot. *Editions Des Archives Contemporaines*. Amsterdam: Gordon and Breach, 1998.

Dupree, A. Hunter. *Asa Gray, 1810-1888*. Cambridge, United Kingdom: Belknap Press, 1959.

———. "The First Darwinian Debate in America: Gray Versus Agassiz." *Daedalus: Proceedings of the American Academy of Arts and Sciences* 88, no. 3 (1959), 560-69.

Editorial. "Obituary: Frederick Jackson Turner." *Geographical Review* 22, no. 3 (1932): 499.

Egerton, Frank N. *Roots of Ecology: Antiquity to Haeckel*. Berkeley: University of California, 2012.

Emerson, George B. "A Notice of Prof. Augustine Pyrame de Candolle." *The American Journal of Science and Arts* 42 (1842): 217–226.

"Engler, Heinrich Gustav Adolf." *Complete Dictionary of Scientific Biography*. 2008. Encyclopedia.com. (September 2, 2016). Available online at: http://www.encyclopedia.com/doc/1G2-2830904874.html

Ewing, Heather P. *The Lost World of James Smithson: Science, Revolution, and the Birth of the Smithsonian*. New York: Bloomsbury, 2007.

Fernald, Merritt Lyndon, and Lily May Perry. *Biographical Memoir of Benjamin Lincoln Robinson, 1864-1935*. Washington, DC: National Academy of Sciences, 1936.

"Fendler, Augustus 1813-1883, Augustus Fendler Papers, 1854, 1874, 1900 and undated." Smithsonian Institution finding aid. SIA RU007446. Available online at: http://siarchives.si.edu/collections/siris_arc_217600

Findling, John E., and Kimberly D. Pelle. *Historical Dictionary of World's Fairs and Expositions, 1851-1988*. New York: Greenwood Press, 1990.

"Fischer, Theobald." *Encyclopaedia Britannica* (12th ed.). Ed. Hugh Chisholm. London & New York: Cambridge University Press, 1922.

Fleming, J. R. "Charles Lyell and Climatic Change: Speculation and Certainty." *Geological Society Special Publication* 143 (1998): 161.

Foster, John Bellamy, and Brett Clark. "The Sociology of Ecology." *Organization & Environment* 21, no. 3 (2008): 311-52.

Foster, M. "Francis Maitland Balfour: Obituary." *British Medical Journal* 2 (July 29, 1882).

"Fries, Elias Magnus." *Encyclopaedia Britannica* (11th ed.). Ed. Hugh Chisholm. UK: Cambridge University Press, 1911.

Gilbert, James Burkhart. *Whose Fair?: Experience, Memory, and the History of the Great St. Louis Exposition*. Chicago: University of Chicago, 2009.

"Girard, Charles Frederic." Department of Vertebrate Zoology, Smithsonian - National Museum of National History. Smithsonian website. Available online at: http://vertebrates.si.edu/fishes/ichthyology_history/ichs_colls/girard_charles.html

Gliboff, Sander. *H.G. Bronn, Ernst Haeckel, and the Origins of German Darwinism: A Study in Translation and Transformation*. Cambridge, Mass.: MIT Press, 2008.

Golinski, Jan. *Making Natural Knowledge: Constructivism and the History of Science*. Chicago: University of Chicago Press, 2005.

Goodale, George Lincoln. *Biographical Memoir of Alexander Agassiz, 1835-1910*. Washington, DC: National Academy of Sciences, 1912.

Gould, Stephen Jay. *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*. Cambridge, Massachusetts: Harvard University Press, 1987.

Gray, Asa, "Benjamin D. Greene," *American Journal of Science and Arts*, 2nd series 35 (1863): 4-19.

Grinnell, Joseph. "Review: The Problem of the Origin of Species." *The Condor* 9, no. 1 (1907): 30-31.

Grisebach, August Heinrich Rudolf. *Die Vegetation Der Erde Nach Ihrer Klimatischen Anordnung: Ein Abriss Der Vergleichenden Geographie Der Pflanzen* [in German]. Leipzig: Engelmann, 1872.

Güttler, Nils Robert. "Scaling the Period Eye: Oscar Drude and the Cartographical Practice of Plant Geography, 1870s–1910s." *Science in Context* 24, No. 1 (2011): 1-41.

"Guyot, Arnold Henry." *Encyclopaedia Britannica* (11th ed.). Ed. Hugh Chisholm. UK: Cambridge University Press, 1911.

Hagen, Joel B. "Clementsian Ecologists: The Internal Dynamics of a Research School." *Osiris* 8 (1993): 178-95.

Haines, George (IV), and Frederick H. Jackson. "A Neglected Landmark in the History of Ideas." *The Mississippi Valley Historical Review* 34, no. 2 (1947): 201-20.

Hanzlik, Christie Cern. "Education Beyond Borders: Exchanging Ideas through World's Fairs, Congresses, and Academic Journals, 1851 to 1904." PhD Thesis, Department of Educational Policy Studies. Madison, Wisconsin: University of Wisconsin-Madison, 2010.

Harrison, Robert Pogue. *The Dominion of the Dead*. Chicago: University of Chicago Press, 2003.

Harvey, E. Newton. *Edwin Grant Conklin, November 24, 1863-November 21, 1952*. Washington, DC: National Academy of Sciences, 1958.

Henig, Robin Marantz. *The Monk in the Garden: The Lost and Found Genius of Gregor Mendel, the Father of Genetics*. Boston: Houghton Mifflin, 2000.

Herber, Elmer Charles. *Correspondence Between Spencer Fullerton Baird and Louis Agassiz, Two Pioneer American Naturalists.* Washington, DC: Smithsonian Institution, 1963.

Hersey, Mark D. "'What We Need Is a Crop Ecologist:' Ecology and Agricultural Science in Progressive-Era America." *Agricultural History* 85, no. 3 (2011): 297-321.

Hottes, Charles F. "The Contributions to Botany of Julius Von Sachs." *Annals of the Missouri Botanical Garden* 19, no. 1 (1932): 15-30.

Hyatt, Alpheus. "Sketch of the Life and Services to Science of Prof. Spencer F. Baird." *Proceedings of the Boston Society for Natural History* (1888): 558-65.

Hyman, Libbie Henrietta. *Charles Manning Child, 1869-1954.* Washington, DC: National Academy of Sciences, 1957.

Irish, Ann B. *Hokkaido: A History of Ethnic Transition and Development on Japan's Northern Island*. Jefferson, North Carolina: McFarland & Co., 2009.

Irmscher, Christoph. *Louis Agassiz: Creator of American Science.* Boston: Houghton Mifflin Harcourt, 2013.

Irvine, William. *Apes, Angels, and Victorians: The Story of Darwin, Huxley, and Evolution*. New York: McGraw-Hill, 1955.

Jackson, Charles Loring. "William Gilson Farlow (1844-1919)." *Proceedings of the American Academy of Arts and Sciences* 57, no. 18 (1922): 484-91.

Jacobs, Wilbur R. "The Many-Sided Frederick Jackson Turner." *The Western Historical Quarterly* 1, no. 4 (1970): 363-72.

Jarausch, Konrad Hugo. *Out of Ashes: A New History of Europe in the Twentieth Century*. New Jersey: Princeton University Press, 2015.

Jenkins, Phil, and George Mercer Dawson. *Beneath My Feet: The Memoirs of George Mercer Dawson*. Toronto: McClelland and Stewart, 2007.

Junker, Thomas. "The Eclipse and Renaissance of Darwinism in German Biology (1900-1950)." In *The Reception of Charles Darwin in Europe.* Ed. Eve-Marie Engels and Thomas F. Glick. London: Continuum, 2008.

Kastor, Peter J. *The Nation's Crucible: The Louisiana Purchase and the Creation of America*. New Haven: Yale University, 2004.

Keeney, Elizabeth. *The Botanizers: Amateur Scientists in Nineteenth-Century America*. Chapel Hill: University of North Carolina, 1992.

Keller, David R., and Frank B. Golley. *The Philosophy of Ecology: From Science to Synthesis.* Athens: University of Georgia, 2000.

Kingsland, Sharon E. *The Evolution of American Ecology, 1890-2000*. Baltimore: Johns Hopkins University Press, 2005.

Kohlstedt, Sally Gregory. *The Formation of the American Scientific Community: The American Association for the Advancement of Science*, 1848-60. Urbana: University of Illinois, 1976.

———. "Nature, Not Books: Scientists and the Origins of the Nature-Study Movement in the 1890s." *Isis* 96, no. 3 (2005): 324-52.

Krey, A. C. "My Reminiscences of Frederick Jackson Turner." *Arizona and the West* 3, no. 4 (1961): 377-81.

Kricher, John. *The Balance of Nature: Ecology's Enduring Myth*. Princeton: Princeton University Press, 2009.

Kukla, Jon. *A Wilderness So Immense: The Louisiana Purchase and the Destiny of America*. New York: A.A. Knopf, 2003.

Lang, W. H. "Fredrick Orpen Bower, 1855-1948." *Obituary Notices of Fellows of the Royal Society* (1949): 1948-49

Langenheim, Jean. "Early History and Progress of Women Ecologists." *Annual Review of Ecology and Systematics* 27 (1996): 1-53.

Langley, Samuel Pierpont and Randolph Iltyd Geare. *A Memorial of George Brown Goode: Together with a Selection of His Papers on Museums and on the History of Science in America*. Washington, DC: US Government Printing Office, 1901.

Laubichler, Manfred. "Carl Gegenbaur (1826-1903): Integrating Comparative Anatomy and Embryology." *Journal of Experimental Zoology* 300, no.1 (2003): 23–31.

Lear, Linda J. *Rachel Carson: Witness for Nature*. New York: H. Holt, 1997.

Lear, Linda J. “Rachel Carson’s Silent Spring.” *Environmental History Review* 17, no. 2 (1993): 23-48.

Lewis, Merrill. “Language, Literature, Rhetoric, and the Shaping of the Historical Imagination of Frederick Jackson Turner.” *Pacific Historical Review* 45, no. 3 (1976): 399-424.

Lindsay, Debra. *Science in the Subarctic: Trappers, Traders, and the Smithsonian Institution*. Washington, DC: Smithsonian Institution, 1993.

Loison, Laurent. “French Roots of French Neo-Lamarckians, 1879-1985.” Journey of the History of Biology 44, no. 4 (2011), 713-44.

Lowenthal, David. “Nature and Morality from George Perkins Marsh to the Millennium.” *Journal of Historical Geography* 26, no. 1 (2000): 3-23.

Lurie, Edward. *Louis Agassiz: A Life in Science*. Chicago: University of Chicago, 1960.

Lützeler, Paul Michael. “The St. Louis World’s Fair of 1904 as a Site of Cultural Transfer: German and German-American Participation.” In *German Culture in Nineteenth-Century America: Reception, Adaptation, Transformation.* Eds. Lynne Tatlock and Matt Erlin. Rochester: Camden House, 2005.

MacDowell, E. Carleton. “Charles Benedict Davenport, 1866-1944: A Study of Conflicting Influences.” *Bios* 17, no. 1 (1946): 2-50.

Manning, Patrick. *Navigating World History: Historians Create a Global Past*. New York: Palgrave Macmillan, 2003.

Marcou, Jules. *Life, Letters and Works of Louis Agassiz*. New York and London: Macmillan and Co, 1896.

Martin, Jason Grek. “Making Settler Space: George Dawson, the Geological Survey of Canada and the Colonization of the Canadian West in the Late 19th Century.” PhD Thesis, Department of Geography. Kingston, Ontario: Queens University, 2009. Available online at: http://hdl.handle.net/1974/5142

Mayr, Ernst. *The Growth of Biological Thought: Diversity, Evolution, and Inheritance.* Cambridge, Massachusetts: Belknap Press, 2003.

McCalman, Iain. *Darwin’s Armada: Four Voyages and the Battle for the Theory of Evolution*. New York: W.W. Norton & Co., 2009.

McIntosh, Robert. *The Background of Ecology: Concept and Theory.* Cambridge, United Kingdom: Cambridge University Press, 1985.

Merrill, Elmer D. *Biographical Memoir of Nathaniel Lord Britton, 1859-1934*. Washington, DC: National Academy of Sciences, 1938.

Midgley, Mary. *Animals and Why They Matter*. Athens: University of Georgia Press, 1998.

Morange, Michael. "What History Tells Us: XXII, the French Neo-Lamarckians." *Journal of Biosciences* 35, no. 4 (2010): 515-17.

Morse, Edward Sylvester. *Biographical Memoir of Charles Otis Whitman, 1842-1910*. Washington, DC: National Academy of Sciences, 1912.

Münsterberg, Margarete A. *Hugo Münsterberg, His Life and Work*. D. Appleton and Company, 1922. Available online at: http://catalog.hathitrust.org/api/volumes/oclc/519668.html.

Numbers, Ronald L. *The Creationists*. New York: A.A. Knopf, 1992.

Nye, Mary Jo. "Historical Sources of Science-as-Social-Practice: Michael Polanyi's Berlin." *Historical Studies in the Physical and Biological Sciences* 37, no. 2 (2007): 409-34.

Nyhart, Lynn K. *Modern Nature: The Rise of the Biological Perspective in Germany*. Chicago: University of Chicago, 2009.

———. *Biology Takes Form: Animal Morphology and the German Universities, 1800-1900*. Chicago: University of Chicago, 1995.

Oliver, F.W. "Dukinfield Henry Scott 1854-1934." *New Phytologist* 33 no. 2 (1934): 73

Oppenheimer, J.M. "Hans Driesch and the Theory and Practice of Embryonic Transplantation.» *Bulletin of the History of Medicine* 44 no. 4 (1970): 378–82.

Osborn, Henry Fairfield. *Biographical Memoir of Edward Drinker Cope, 1840-1897*. Washington, DC: National Academy of Science, 1930.

———. *Impressions of Great Naturalists: Reminiscences of Darwin, Huxley, Balfour, Cope and Others*. New York: Scribner, 1924.

Overfield, Richard A. "Charles E. Bessey: The Impact of the 'New' Botany on American Agriculture, 1880-1910." *Technology and Culture* 16, no. 2 (1975): 162-81.

Parezo, Nancy J. *Anthropology Goes to the Fair: The 1904 Louisiana Purchase Exposition.* Critical Studies in the History of Anthropology. Lincoln: University of Nebraska Press, 2007.

Pettijohn, F. J. *Rollin Thomas Chamberlin: October 20, 1881-March 6, 1948*. Washington, DC: National Academy of Sciences, 1970.

Polanyi, Michael. *Personal Knowledge: Towards a Post-Critical Philosophy*. Chicago: University of Chicago Press, 1958.

Powell, William S. *Moses Ashley Curtis, 1808-1872: Teacher, Priest, Scientist.* Chapel Hill: University of North Carolina Library, 1958.

Rademacher, Diane. *Still Shining: Discovering Lost Treasures from the 1904 St. Louis World's Fair*. St. Louis: Virginia Publishing, 2003.

Rainger, Ronald. *An Agenda for Antiquity: Henry Fairfield Osborn and Vertebrate Palaeontology*

at the American Museum of Natural History, 1890-1935. Tuscaloosa: University of Alabama, 1991.

———. "Palaeontology and Philosophy: A Critique." *Journal of the History of Biology* 18, no. 2 (1985): 267-87.

———. "The Continuation of the Morphological Tradition: American Palaeontology,1880-1910." *Journal of the History of Biology*, no. 1 (1981): 129-58.

Raup, Hugh M. "Charles C. Adams, 1873-1955." *Annals of the Association of American Geographers* 49, no. 2 (1959): 164-67.

Regal, Brian. *Henry Fairfield Osborn: Race, and the Search for the Origins of Man*. Aldershot, United Kingdom: Ashgate, 2002.

Rhea, John M. *A Field of Their Own: Women and American Indian History, 1830-1941*. Norman, Oklahoma: University of Oklahoma, 2016.

Richards, Robert J. *The Tragic Sense of Life: Ernst Haeckel and the Struggle over Evolutionary Thought*. Chicago: University of Chicago, 2008.

Riddle, Brett R. "Is Biogeography Emerging from Its Identity Crisis?" *Journal of Biogeography* 32, no. 2 (2005): 185-86.

Ridge, Martin. "A More Jealous Mistress: Frederick Jackson Turner as Book Reviewer." *Pacific Historical Review* 55, no. 1 (1986): 49-63.

Rieppel, Olivier. *Phylogenetic Systematics: Haeckel to Hennig*. Florida: Taylor and Francis, 2016.

Riordan, Colin. *Green Thought in German Culture: Historical and Contemporary Perspectives*. Cardiff: University of Wales, 1997.

Robinson, Benjamin Lincoln. *Biographical Memoir for George Lincoln Goodale: 1839-1923*. Washington, DC: National Academy of Sciences, 1924.

Ronda, James. "American Exploration in the Age of Jefferson." In *A Continent Comprehended.* Ed. John Logan Allen. North American Exploration. Lincoln: University of Nebraska Press, 1997.

Rudwick, Martin J. S. *Bursting the Limits of Time: The Reconstruction of Geohistory in the Age of Revolution*. Chicago: University of Chicago Press, 2005.

———. *The Great Devonian Controversy: The Shaping of Scientific Knowledge among Gentlemanly Specialists*. Chicago: The University of Chicago Press, 1988.

Sachs, Aaron. *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism*. London: Penguin Books, 2007.

Sachs, Julius. *Lehrbuch Der Botanik: Nach Dem Gegenwärtigen Stand Der Wissenschaft* [in German]. Leipzig: W. Engelmann, 1868.

Scaff, Lawrence A. *Max Weber in America*. Massachusetts: Princeton University Press, 2011.

Schaefer, B. E. *The Man Behind Moriarty*. Cambridge, Massachusetts: Sky Publishing Company, 1993.

———. "Sherlock Holmes and Some Astronomical Connections." *Journal of the British Astronomical Association* 103, no.1 (1993): 31-34.

Secord, James A. *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation*. Chicago: University of Chicago Press, 2000.

Setchell, William Albert. *Biographical Memoir of William Gilson Farlow, 1844-1919*. Washington, DC: National Academy of Sciences, 1926.

Sheets-Pyenson, Susan. *Cathedrals of Science: The Development of Colonial Natural History Museums During the Late Nineteenth Century*. Kingston, Ontario: McGill-Queen's University Press, 1988.

Shine, Ian, and Sylvia Wrobel. *Thomas Hunt Morgan: Pioneer of Genetics*. Lexington, Kentucky: University of Kentucky Press, 2009.

Sidar, Jean Wilson. *George Hammell Cook: A Life in Agriculture and Geology*. New Jersey: Rutgers University Press, 1976.

Siesser, W.G. "Christian Gottfried Ehrenberg: Founder of Micropaleontology." *Centaurus* 25, no. 3 (1981): 166–88.

Simmons, John. *Doctors and Discoveries: Lives That Created Today's Medicine*. Boston: Houghton Mifflin, 2002.

Sloan, Phillip Reid. "The Buffon-Linnaeus Controversy." *Isis* 67 (1976): 356-75.

———. "Buffon, German Biology, and the Historical Interpretation of Biological Species." *The British Journal for the History of Science* 12, no. 2 (1979): 109-53.

Slotten, Ross A. *The Heretic in Darwin's Court: The Life of Alfred Russel Wallace*. New York: Columbia University Press, 2004.

Smith, Charles H., Joshua Woleben, and Carubie Rodger. "Aimé Jacques Alexandre (Goujaud) Bonpland." In *Some Biogeographers, Evolutionists and Ecologists: Chrono-Biographical Sketches* (2012). Paper 52, DLPS Faculty Publications.

Speak, Peter. *William Speirs Bruce: Polar Explorer and Scottish Nationalist*. Edinburgh: National Museums of Scotland, 2003.

Spillmann, Jutta, and Lothar Spillmann. "The Rise and Fall of Hugo Münsterberg." *Journal of the History of the Behavioral Sciences* 29, no. 4 (1993): 322-38.

Spiro, Jonathan Peter. *Defending the Master Race: Conservation, Eugenics, and the Legacy of Madison Grant.* Burlington: University of Vermont Press, 2009.

Spry, Irene M. *The Palliser Expedition: The Dramatic Story of Western Canadian Exploration, 1857-1860*. Western Canadian Classics. Saskatoon: Fifth House Publishers, 1995.

Stehr, Nico. *Eduard Brückner: The Sources and Consequences of Climate Change and Climate Variability in Historical Times*. Dordrecht: Kluwer Academic Publishers, 2000.

Stocking, George W. "Adolf Bastian and the Psychic Unity of Mankind. The Foundations of Anthropology in Nineteenth-Century Germany." *Medical History* 29, no. 3 (1985): 338-39.

———. "Franz Boas and the Culture Concept in Historical Perspective." *American Anthropologist* 68, no. 4 (1966): 867-82.

Sturtevant, A. H. *Biographical Memoir of Thomas Hunt Morgan, September 25, 1866-December 4, 1945.* Washington, DC: National Academy of Sciences, 1959.

Sulloway, Frank J. *The Beagle Collections of Darwin's Finches (Geospizinae)*. London: British Museum of Natural History, 1982.

Tansley, Arthur. "The Early History of Modern Plant Ecology in Britain." *The Journal of Ecology* 35, no. 1/2 (1947): 130.

Tatlock, Lynne, and Matt Erlin. *German Culture in Nineteenth-Century America: Reception, Adaptation, Transformation*. Rochester: Camden House, 2005.

Teller, James D. "Huxley's 'Evil' Influence." *The Scientific Monthly* 56, no. 2 (1943): 173-78.

Thom, Charles. *George Francis Atkinson, 1854-1918*. Washington, DC: National Academy of Sciences, 1956.

Thorson, Robert M. *Walden's Shore: Henry David Thoreau and Nineteenth-Century Science*. Cambridge, Massachusetts: Harvard University Press, 2015.

Tobey, Ronald C. *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895-1955*. Berkeley: University of California, 1981.

Trelease, William. *Biographical Memoir of John Merle Coulter, 1851-1928*. Washington, DC: National Academy of Sciences, 1929.

———. "Thomas Jonathan Burrill: April 25, 1839-April 14, 1916." *Botanical Gazette* 62, no. 2 (1916): 153-55.

Turner, Frederick Jackson, and John Mack Faragher. *Re-Reading Frederick Jackson Turner: The Significance of the Frontier in American History, and Other Essays*. New York: Henry Holt, 1994.

Vucinich, Alexander. *Darwin in Russian Thought*. Berkeley: University of California, 1988.

Walker, J.C. *Biographical Memoir of Benjamin Minge Duggar 1872-1956*. Washington, DC: National Academy of Science, 1958.

Walls, Laura Dassow. *The Passage To Cosmos: Alexander Von Humboldt and the Shaping of America*. Chicago: The University of Chicago Press, 2009.

Western Literature Association. *A Literary History of the American West*. Fort Worth: Texas Christian University Press, 1987.

Wilkinson, David M. "Ecology before Ecology: Biogeography and Ecology in Lyell's 'Principles'." *Journal of Biogeography* 29, no. 9 (2002): 1109-15.

Woodring, W.P. *William Healey Dall, 1845-1928: A Biographical Memoir.* Washington, DC: National Academy of Sciences, 1958.

Worster, Donald. *Nature's Economy: A History of Ecological Ideas*. Cambridge, United Kingdom: Cambridge University Press, 1985 edition (first published 1977).

Wulf, Andrea. *The Invention of Nature: Alexander von Humboldt's New World*. New York: Vintage Books, 2016.

Zeller, Suzanne. "The Colonial World as Geological Metaphor: Strata(Gems) of Empire in Victorian Canada." *Osiris* Vol. 15, Special Issue: Nature and Empire: Science and the Colonial Enterprise (2000): 85-107.

———. *Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation*. Toronto: University of Toronto, 1987.

Zitarelli, David E. "The 1904 St. Louis Congress and Westward Expansion of American Mathematics." *Notices of the American Mathematical Society* 58, no. 8 (2011): 1100-11.