History of Biology

*By Jane Maienschein**

WIDESPREAD INTEREST in American biology is a fairly recent development. Historians, using a variety of methods and representing a range of approaches, have begun to study significant aspects of the subject, though we lack as yet a comprehensive history of biology in the United States. History of science meetings offer numerous symposia each year, and articles and books appear at an increasing rate. The conviction that the field is a fertile and important one has stimulated this inquiry, but what constitutes the field and what is the best way to approach it are unresolved questions. This survey suggests that a diversity of approach and method, relying on a variety of resources and examining a wide range of subjects, remains the best way to deal with both the above questions.

GENERAL TRENDS: WHAT IS AMERICAN BIOLOGY?

Conscious exploration of American biology as a separate subject antedates the current explosion in historical examination. With the establishment in the late nineteenth century of professional biological institutions—the Johns Hopkins University, the University of Chicago, and the Marine Biological Laboratory (MBL)—came considerable discussion about what biology in the United States would be like.[1] This very discussion implied that the participants' convictions that national setting might have an effect on scientific ideas and activity, so that there might be a self-consciously American biology. The very earliest historical studies, however, did not explicitly address the question of how the particular setting might have influenced the science.

In fact, one of the earliest subjects of interest, and the only subject that has consistently attracted scholarly attention, is the notorious mid-nineteenth-century race to collect dinosaur remains. Not always professional histories of science, some of these studies nonetheless stirred the imagination and raised serious questions about the scientific developments that had inspired the fossil seekers. In particular, the energetic debates between Othniel Marsh and Edward Cope over interpretations of the evolutionary history of fossil animals provided such a focus. And such later works as Wayne Hanley's *Natural History in America* place the dinosaur races in the context of natural historical work and ideas more generally, revealing the emphasis on those alternative evolutionary theories.[2]

* Department of Philosophy, Arizona State University, Tempe, Arizona 85287.

[1] See, e.g., Charles Otis Whitman, "Specialization and Organization: Companion Principles of All Progress—The Most Important Need of American Biology," *Biological Lectures*, 1891, *1890*:1–26. See generally the Gilman Collection, Johns Hopkins University Manuscripts Collection; Whitman Papers, University of Chicago Archives; and Agassiz Collection, Museum of Comparative Zoology Archives, Harvard University.

[2] Wayne Hanley, *Natural History in America, from Mark Catesby to Rachel Carson* (New York:

The 1940s and 1950s brought an interest in documenting histories of institutions and groups of individuals. Several series, in *Bios* and the *Turtox News*, for example, appeared to detail the emergence of laboratories or biological departments. Such institutional studies typically focused on personalities or major events and did not seriously examine the intellectual or political roots of the institutions. Nevertheless, these chronologies provide useful information about what individuals contributed, and they do underline the particular local features of the field. In addition, by the 1950s a few biologists had begun to examine the contributions and ideas of individual scientists who had remained theretofore little known. Ralph Dexter provided the most notable example of such work with his study of the group of naturalists located around Salem, Massachusetts, including biographical and group sketches of E. S. Morse, Alpheus Hyatt, A. S. Packard, Frederic W. Putnam, and others.[3]

American biology began to be treated as a serious subject within the context of American history in the 1950s and 1960s. The period brought works that examined the lives of major figures in American biology. From that period, A. Hunter Dupree's biography of botanist Asa Gray and Edward Lurie's biography of zoologist Louis Agassiz remain classics. Each paints a clear and striking portrait of the individual and his life in science. These pioneering scholarly works in the emerging field of history of American biology also provide considerable insight into what role the national setting played in shaping the science, illustrating that the subjects' American context did in fact shape the character of the scientific work done. These studies exemplify the move from chronicling to concern with deeper historical questions.[4]

The 1960s saw historians of science, as distinct from American historians, begin to treat biology in the United States. Their work grew out of a burgeoning interest in the philosophy of science and in the rise of modern science generally, and it reflected the professionalization of history of science, which traditionally had emphasized intellectual history and scientific ideas. Because of this emphasis, the studies from this period generally treat the American setting as of secondary or virtually negligible importance. In his widely read *The Structure of Scientific Revolutions*, Thomas Kuhn argued that science entails community, as well as individual practices. But biology itself—as ideas held by a community—rather than its place in the United States occupied center stage for Kuhn and for these historians.[5] Accordingly, they explored scientific ideas, the relative roles of theory and empirical observation, the role of experimentation, and the

Quadrangle, 1977). In addition, Url Lanham, *The Bone Hunters* (New York: Columbia Univ. Press, 1973), presents a tale of the rough-and-ready, distinctly American competition; and Nathan Reingold, ed., *Science in Nineteenth Century America: A Documentary History* (New York: Hill & Wang, 1964), includes letters that illustrate the debates about bones and evolution.

[3] Ralph Dexter, "The Annisquam Seaside Laboratory of Alpheus Hyatt," *Scientific Monthly*, 1952, *74*:112–116; Dexter, "Three Young Naturalists Afield—The First Expedition of Hyatt, Shaler, and Verrill," *Sci. Mo.*, 1954, *79*:45–51; Dexter, "Excerpts from Alpheus Hyatt's Log of the *Arethusa*," *Essex Institute Historical Collections*, 1954, *90*:229–260; and Dexter, "The 'Salem Secession' of Agassiz Zoologists," *Essex Inst. Hist. Coll.*, 1965, *101*:27–39.

[4] A. Hunter Dupree, *Asa Gray* (Cambridge, Mass.: Harvard Univ. Press, 1959); Edward Lurie, *Louis Agassiz: A Life in Science* (Chicago: Univ. Chicago Press, 1960); and Lurie, *Nature and the American Mind: Louis Agassiz and the Culture of Science* (New York: Science History, 1974).

[5] Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: Univ. Chicago Press, 1962).

advent of modern science, taking for granted the setting in which these developments were unfolding.

There are other works in the intellectual tradition which directly treat biology that took place in the United States, though they do not address whether it is peculiarly American biology. Elof Carlson's *The Gene: A Critical History*, written in the 1960s, examines a special area of biology and emphasizes work done in the United States. More recent efforts in this vein include Donna Haraway's imaginative study of the use of metaphor by three embryologists, one of whom (Ross Granville Harrison) was American. Likewise, Scott Gilbert's study of Thomas Hunt Morgan's developmental biology concentrates on ideas in embryology and genetics that happened to appear in the United States, although he does not identify them as particularly American in any way. Garland Allen's early studies of Thomas Hunt Morgan, Edward Manier's look at Morgan's experimental approach, Alice Levine Baxter's examination of Edmund Beecher Wilson's cytology, and John Farley's several chapters on largely American work in *Gametes and Spores* further exemplify this tradition. Two overviews that also remain firmly in the tradition of intellectual history are Ernst Mayr's opus *The Growth of Biological Thought*, with its instructive historiographic introduction, and Allen's *Life Science in the Twentieth Century*. The latter author reviews modern biology, much of which is American, but neither he nor his critics, who have advanced alternative interpretations of the early twentieth-century morphological tradition and the other scientific ideas and methods he discusses, have addressed the American setting in particular.[6]

Extreme examples of this approach have been labeled "internalist" history of science and have been criticized for ignoring nonintellectual factors which, critics argue, also direct science. While a history of ideas alone obviously cannot uncover all aspects of the history of science, so long as the intellectual historian understands that he or she is in effect looking through a narrowing lens and thus allowing much of the context of science to remain out of focus, then the approach can be acceptable. But a more subtle limitation is that by emphasizing ideas such studies have often tended to address periods of dramatic scientific change and hence, in the history of biology, to concentrate on the post-Darwinian era while neglecting earlier contributions. Charles Rosenberg's overview

[6] Elof Alex Carlson, *The Gene: A Critical History* (Philadelphia: Saunders, 1966); Carlson, *Genes, Radiation, and Society: The Life and Work of H. J. Muller* (Ithaca, N.Y.: Cornell Univ. Press, 1981); Donna J. Haraway, *Crystals, Fabrics, and Fields: Metaphors of Organicism in Twentieth-Century Developmental Biology* (New Haven: Yale Univ. Press, 1976); Scott Gilbert, "The Embryological Origins of the Gene Theory," *Journal of the History of Biology*, 1978, *11*: 307–351; Garland Allen, "Thomas Hunt Morgan and the Problem of Sex Determination, 1903–1910," *Proceedings of the American Philosophical Society*, 1966, *110*:48–57; Allen, "T. H. Morgan and the Emergence of a New American Biology," *Quarterly Review of Biology*, 1969, *44*:168–188; Edward Manier, "The Experimental Method in Biology: T. H. Morgan and the Theory of the Gene," *Synthese*, 1969, *20*:185–205; Alice Levine Baxter, "Edmund Beecher Wilson and the Problem of Development: From the Germ Layer Theory to the Chromosome Theory of Inheritance" (Ph.D. diss., Yale Univ., 1974); Baxter, "E. B. Wilson's 'Destruction' of the Germ-Layer Theory," *Isis*, 1977, *68*:363–374; Baxter, "Edmund B. Wilson as Preformationist: Some Reasons for His Acceptance of the Chromosome Theory," *J. Hist. Biol.*, 1976, 9:29–57; John Farley, *Gametes and Spores: Ideas about Sexual Reproduction, 1750–1914* (Baltimore: Johns Hopkins Univ. Press, 1982); Ernst Mayr, *The Growth of Biological Thought: Diversity, Evolution, and Inheritance* (Cambridge, Mass.: Harvard Univ. Press, 1982); Allen, *Life Science in the Twentieth Century* (New York: Wiley, 1975); and Jane Maienschein, Keith Benson, and Ronald Rainger in "Special Section on American Morphology at the Turn of the Century," *J. Hist. Biol.*, 1981, *14*:83–158.

of internalist and externalist approaches in the history of science, outlining the strengths and weaknesses of each, is a sensible and useful guide to these broad traditions.[7]

The externalist tradition also finds its representatives in the history of biology. That approach emerged explicitly in the late 1960s and early 1970s as part of the more general move within history toward social history. It concentrated primarily on external, or institutional and social, settings. This approach also has its critics, who have argued that much institutional and social history deals only secondarily with the intellectual content, as though neither theories nor empirical studies mattered and science were nothing more than the product of its setting. Fortunately historians of biology have generally avoided such extreme externalism.

Probably the largest area of inquiry that has continued to attract primarily social and political rather than intellectual analysis is eugenics. Since particular eugenics arguments so clearly exhibit national differences and depend on social and political factors, historians have accepted an external approach to the subject as appropriate. Major studies of American eugenics include Mark Haller's *Eugenics* and Kenneth Ludmerer's *Genetics and American Society*, both of which concentrate on the social uses of science. Written from the context of American social history, these books also examine the science of genetics behind social discussions and policy decisions. In a related study, Hamilton Cravens examines changing attitudes to the nature-nurture controversy in the United States. A number of recent works have explored various elements of the eugenics movements as well, most notably Daniel Kevles's highly praised series in the *New Yorker*.[8]

Another recent provocative study of the way in which extraintellectual factors can direct science is Diane Paul's examination of genetics textbooks. She reports that even though the infamous twin studies by psychologist Cyril Burt have been resoundingly discredited (as detailed in Leslie Hearnshaw's biographical assessment of Burt), many textbooks continue to cite them. Furthermore, a majority of textbooks, most of them American, still maintain Burt's conclusion that intelligence is strongly heritable, even relying on his discredited results as evidence. Paul's emphasis on nonintellectual factors such as the politics of textbook writing and the politics of inheritance theories is appropriate in this case, where the extrascientific factors seem clearly to have dictated what is presented in textbooks as the currently best scientific ideas.[9]

In another example, Robert Kohler has been accused by some of adopting an overly externalist view in his history of biochemistry, *From Medical Chemistry to Biochemistry*. He does at times sound as though he were disregarding the ideas of science. Yet a careful reading proves the criticism unfair. Indeed,

[7] Charles Rosenberg, "On the Study of American Biology and Medicine: Some Justifications," *Bulletin of the History of Medicine*, 1964, *38*:364–376.

[8] Mark H. Haller, *Eugenics: Hereditarian Attitudes in American Thought* (New Brunswick, N.J.: Rutgers Univ. Press, 1963); Kenneth Ludmerer, *Genetics and American Society: A Historical Appraisal* (Baltimore: Johns Hopkins Univ. Press, 1972); Hamilton Cravens, *Triumph of Evolution: American Scientists and the Heredity-Environment Controversy* (Philadelphia: Univ. Pennsylvania Press, 1978); and Daniel Kevles, "Annals of Eugenics," *New Yorker*, 1984, 8 Oct., pp. 51–115, 15 Oct., pp. 52–125, 22 Oct., pp. 92–151, and 29 Oct., pp. 51–117.

[9] Diane Paul, "Textbook Treatments of the Genetics of Intelligence," *Quart. Rev. Biol.*, 1985, forthcoming; Leslie Hearnshaw, *Cyril Burt, Psychologist* (Ithaca, N.Y.: Cornell Univ. Press, 1979).

Kohler provides an unusual example of what a good and original institutional history can be. His work is complex and occasionally dry with detail, but it nonetheless yields an important perspective on a specialty within American biology and chemistry. Kohler staunchly maintains that scientific disciplines are political institutions that rise and fall as other political institutions do. They do not reflect essential, fixed categories in nature, and thus they may vary greatly from one setting to another. For example, he argues that American biochemistry's close alliance with medicine made theoretical changes in molecular biology more difficult. For Kohler, institutional factors strongly limit and direct science, a view very different from that of the intellectual historian. But he does not claim that ideas are irrelevant.[10]

One unusual study that embraces both internalist and externalist approaches considers British rather than American biology. Gerald Geison's examination of Michael Foster's school of physiology provides a model in weaving together analysis of such factors as the individual scientist, scientific ideas, the roles of other participants working together in the school, the establishment of a discipline that was successful depite its lack of brilliant or useful results, the institutional setting, and the political climate.[11] Historians of science in America are only beginning to embrace similarly sophisticated and productive approaches, providing examples of diverse approaches to the history of American biology.

These examples of internal and external approaches, all representing history of biology that occurred in America, demonstrate a robust diversity. Yet history of American biology can also be cut up in different ways as historians regard one or another interpretation of American biology as more appropriate. For some, American biology is implicitly treated as that set of biological ideas which appeared in the United States; for them intellectual history is the appropriate approach. For others, who regard American biology as that biology practiced by important figures, biographical studies seem the proper point of attack. Still others see leading institutions that direct science as the significant factor; they therefore pursue institutional history at various levels. For yet others, American biology is an activity pursued in characteristically different ways in its American setting and influenced by that setting; for them, social and political history will figure centrally in the story of American biology. Biographies, institutional histories, and histories of disciplines thus emerge as the major representative categories of historical works, with other less traditional works appearing as well. Diversity of approach remains productive and desirable as long as the question about what constitutes American biology remains open to a variety of answers.

SOURCES

Some historians of science have begun to pursue traditional subjects through heretofore underutilized sources of information. For example, William Provine's extensive study of Sewall Wright draws heavily on interviews, notebooks, and reprint collections, seeking a system to grapple with the wealth of materials available for living (and recently deceased) figures in science. As F. L. Holmes

[10] Robert E. Kohler, *From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline* (Cambridge/New York: Cambridge Univ. Press, 1982).

[11] Gerald Geison, *Michael Foster and the Cambridge School of Physiology: The Scientific Enterprise in Late Victorian Society* (Princeton, N.J.: Princeton Univ. Press, 1978).

has pointed out, there is room to explore the "fine structure of scientific creativity."[12] Generally, however, interest in twentieth-century biology has not prompted the use of oral history, on which historians of physics and chemistry have begun to rely, so living biologists remain a major resource as yet largely untapped.

Printed materials are still the central source of historiographic information. Yet reprint collections such as that at the MBL and other collections in libraries are often overlooked. They can, obviously, prove especially valuable when they are annotated by a known hand. In addition, many universities and the American Philosophical Society have amassed valuable archival collections of American biologists. Librarians and administrators are becoming more aware of the worth of their archival resources and the need to make these materials available to scholars, so more collections have been opened. *The Mendel Newsletter*, edited by Frederick Churchill, and David Bearman and John Edsall's *Archival Sources* can help point the way to manuscripts, as can the collections of letters edited by Nathan Reingold and Ida Reingold. For biographical data to guide research, the *Dictionary of Scientific Biography* continues to add supplements, while such works as Joseph Ewan and Nesta Ewan's *Biographical Dictionary of Rocky Mountain Naturalists* provide information on more specialized groups of individuals.[13]

Historians of biology can also profit greatly from the reissue of important texts. As out-of-print books become increasingly expensive and inaccessible and as new graduates move away from major libraries, availability becomes problematic. Thus the reissue by Columbia University Press and Yale University Press of such works as Theodosius Dobzhansky's *Genetics and the Origin of Species*, Mayr's *Systematics and the Origin of Species*, and Richard Goldschmidt's *Material Basis of Evolution* is important. Similarly, the volumes produced by Arno Press, such as the series on the history of paleontology edited by Steven Jay Gould and Thomas Schopf and the volumes in natural history edited by Keir Sterling, represent valuable but underutilized materials.[14]

[12] William Provine, *Sewall Wright: Geneticist and Evolutionist* (Chicago: Univ. Chicago Press, forthcoming); F. L. Holmes, "The Fine Structure of Scientific Creativity," *History of Science*, 1981, *19*:60–70.

[13] Frederick B. Churchill, ed., *The Mendel Newsletter* (Philadelphia: Library of the American Philosophical Society); David Bearman and John T. Edsall, eds., *Archival Sources for the History of Biochemistry and Molecular Biology: A Reference Guide and Report*, 1980 (Boston: American Academy of Arts and Sciences; Philadelphia: American Philosophical Society, 1980); Nathan Reingold and Ida Reingold, eds., *Science in America: A Documentary History, 1900–1939* (Chicago: Univ. Chicago Press, 1981); Nathan Reingold, ed., *Science in Nineteenth Century America* (cit. n. 2); Charles Gillispie, ed., *Dictionary of Scientific Biography* (New York: Scribners, 1970–1980); Supplement II, forthcoming, ed. F. L. Holmes; and Joseph Ewan and Nesta Ewan, *Biographical Dictionary of Rocky Mountain Naturalists: A Guide to the Writings and Collections of Botanists, Zoologists, Geologists, Artists, and Photographers, 1682–1932* (The Hague/Boston: W. Iuwer, Boston, 1981).

[14] The Arno reprint series includes works by Alpheus Hyatt, Alfred Sherwood Romer and Llewellyn I. Price, George Gaylord Simpson, Henry Fairfield Osborn, Louis Agassiz, Edward Drinker Cope, William King Gregory, and Joseph Leidy; see also Keir Sterling, *Last of the Naturalists: The Career of C. Hart Merriam* (New York: Arno, 1977); Sterling, ed., *Contributions to the History of American Natural History* (New York: Arno, 1974); Theodosius Dobzhansky, *Genetics and the Origin of Species* (New York: Columbia Univ. Press, 1970); Dobzhansky, *Dobzhansky's Genetics of Natural Populations* ed. R C. Lewontin, John A. Moore, William B. Provine, and Bruce Wallace (New York: Columbia Univ. Press, 1981); Ernst Mayr, *Systematics and the Origin of Species* (New York: Columbia Univ. Press, 1982), intro. by Niles Eldredge; and Richard Goldschmidt, *The Material Basis of Evolution* (New Haven: Yale Univ. Press, 1982) intro. by Stephen Jay Gould.

Just as histories of biology tend to group together under the broad categories of biographies, institutional histories, and disciplinary histories, depending on each historian's definition of the problem at hand, so different resources can prove particularly useful. For biographies, therefore, oral histories, notebooks, and reprint collections can provide an extra dimension of information. Institutional histories are often strengthened by archival sources and administrative records, though these often remain difficult to locate. Disciplinary histories can profit from the increased availability of a wide range of primary resources through reprints and manuscripts spanning the disciplinary area.

BIOGRAPHIES

Mary Alice Evans and Howard Ensign Evans's study of Harvard entomologist William Morton Wheeler is an excellent portrait of the man as scientist within a particular social and political setting. It details the development of Wheeler's work on wasps, at the same time discussing the way in which that work emerged against a background of Wheeler's education at Clark University and positions at the University of Chicago, the University of Texas, and the American Museum of Natural History, with visits to the Naples Zoological Station and the MBL. The Evanses combine an understanding of the scientific contributions with details of Wheeler's life and personality.[15]

Another biography, by Garland Allen, has traced chronologically the development of one man's science, Thomas Hunt Morgan's genetics. Allen defends the thesis that biology underwent a revolution from morphological to experimental and that Morgan contributed centrally to effecting that change. Allen's work, while primarily a study of one man's science rather than a personal history or a thorough consideration of setting, details an important story of intellectual development that reflects both personal and institutional elements.[16]

In a different sort of study, Kenneth Manning provides a marvelously vital portrait of a black scientist in a scholarly biography that includes considerable personal and social history. Manning's study of Ernest Everett Just weaves together institutional history (the Rockefeller Foundation, MBL, Howard University), personal details (family life, friendships, love affairs), social history (southern upbringing, race, the Spingarn prize, Howard University, connections with Frank Lillie, Jacques Loeb, and the MBL), national differences in scientific style (American, German, French), and Just's science. By portraying one scientist, Manning believes he will reveal a great deal about the institution of science. Was Just denied opportunity in the United States because he was black? Clearly, yes. How good a scientist was he and how different should his professional position have been? Manning suggests that Just was an excellent scientist, but he does not explicitly argue the point. Instead, he draws on an impressive range of sources to illustrate the pressures, demands, and limitations Just confronted as a black scientist in the United States. Throughout this book, Manning raises questions about how different factors influence scientific ideas and institutions that historians of biology should pursue. He stimulates the reader to

[15] Mary Alice Evans and Howard Ensign Evans, *William Morton Wheeler, Biologist* (Cambridge, Mass.: Harvard Univ. Press, 1970).

[16] Garland Allen, *Thomas Hunt Morgan: The Man and His Science* (Princeton, N.J.: Princeton Univ. Press, 1978).

consider related problems as well. In addition, Manning's powerful narrative underlines the value of writing history well.[17]

Evelyn Fox Keller's biography of Barbara McClintock is a fairly straightforward description of McClintock's life and work. Keller does not inquire into scientific change or the individual's place in a complex historical setting. Rather, she wants to convince her readers that McClintock has faced peculiar problems because she is a woman, a thesis that surely has merit although McClintock herself insists that she is different, that she savors the exceptions rather than the rules in nature, and that therefore her own situation cannot be explained as the problem of a class of people—namely women—generally. Keller's treatment of McClintock as an exemplar thus weakens her study. The work also demonstrates the advantages and the problems of writing about a living scientist. In brief, while Keller's biography has reached a wider audience than most histories of biology, the work reveals a lack of objectivity resulting from the author's necessary reliance on interviews and personal acquaintance with her subject.[18]

Autobiographies offer similar problems of objectivity. Nevertheless, such delightful works as G. Evelyn Hutchinson's *Kindly Fruits of the Earth* and such reflections as Mayr's "How I Became a Darwinian," George Gaylord Simpson's *Concession to the Improbable*, and Edwin Colbert's *A Fossil Hunter's Notebook: My Life with Dinosaurs and Other Friends* provide valuable insights into the workings of biology and its setting. They can serve as both primary and secondary sources, for they often provide historical interpretations of the ideas and settings of an earlier time.[19]

Other problems come with studying relatively unknown or undocumented scientists. For example, Marilyn Ogilvie and Clifford Choquette had to probe local records and contact relatives and friends for information on cytologist Nettie Stevens. Though some of Stevens's work on chromosomes has been discussed, for example, in Stephen Brush's article on her work on sex determination, personal details have generally not been available. Ogilvie's recent study of Alice Boring called for similar tactics. The resulting picture of individuals who have contributed important scientific ideas while remaining in relative personal obscurity is invaluable.[20] Many other such life stories remain to be constructed from oral histories and local or family records.

INSTITUTIONS

Biological institutions provide another subject of serious study. Historians have begun to move beyond chronologies toward more sophisticated analyses of the nature and significance of various institutions. Mary P. Winsor's examination of Louis and Alexander Agassiz and the Museum of Comparative Zoology (MCZ) at Harvard University offers one example.[21] The MCZ's role as the primary academic center for natural history and hence biological research in the mid-nineteenth century, as well as the powerful and long-term influence of the Agassiz father and son, indicate the ability of individuals to shape the scientific work within an organization under tight administrative control. The rich materials in the well-organized MCZ archives (some on microfilm) make that institution a promising source of materials and subject for further study.

The Johns Hopkins University biology program has also received attention, largely because of its critical importance in attracting a group of American investigators to solid morphological work, as well as in setting new directions in biological research in the 1880s and 1890s. Philip Pauly has looked at the relations of psychology to biology in Hopkins's early years under G. Stanley Hall, for example, and has discovered a lack of communication between practitioners of the two areas of study. Also looking at the Johns Hopkins, Dennis McCullough and Keith Benson have examined the impact of William Keith Brooks on morphological work there in the 1890s.[22] Unfortunately, the roots of physiological investigation in the biology program at Hopkins have remained largely unexamined, as has the period after the "golden age" of the nineteenth century.

The University of Chicago has also received some attention but warrants much more. Lincoln Blake, for example, has provided an unsophisticated introduction to science at Chicago, with a bare sketch of the chronology of what happened in the early years.[23] Despite the lack of a large organized archival collection on the early years, the University of Chicago and the Lillie and Whitman Collections at the MBL do contain a number of documents that should inform a much richer study of Chicago and the principals involved than has yet appeared. In particular Charles Otis Whitman, first head of biology at Chicago and first director of the MBL, had strong ideas about what biology meant: morphology and physiology, zoology and botany, descriptive and experimental work. In organizing both institutions, he stubbornly held to his convictions about biology but stepped aside from administrative control in the early 1900s. Whitman's student Frank Lillie took over both the MBL and the Chicago department, in turn imposing his own strong ideas about biology. Both men were so closely tied with these institutions that biography and institutional history need to be written together. In addition, each man in his own way stressed the importance of the whole organism, examination of which promises significant

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[17] Kenneth B. Manning, *Black Apollo of Science: The Life of Ernest Everett Just* (New York: Oxford Univ. Press, 1983).

[18] Evelyn Fox Keller, *A Feeling for the Organism: The Life and Work of Barbara McClintock* (San Francisco: Freeman, 1983).

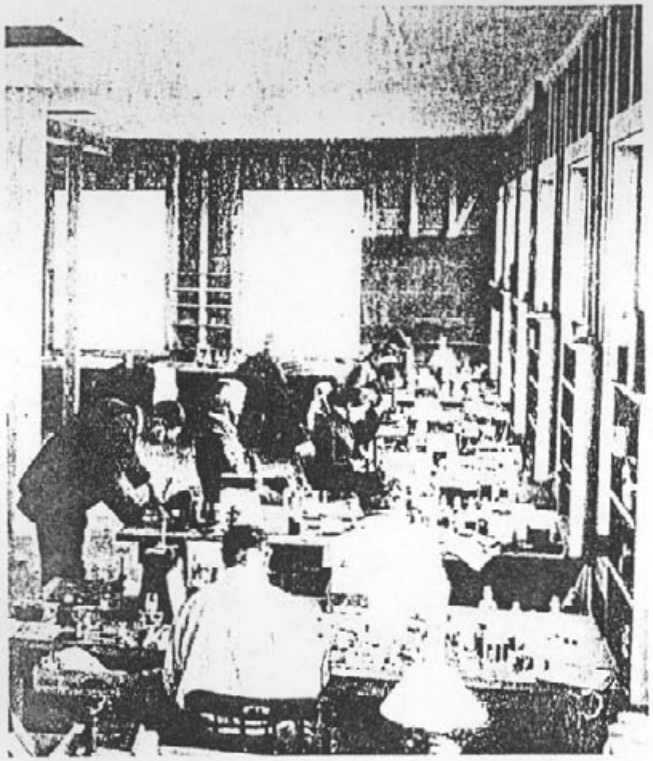
[19] G. Evelyn Hutchinson, *Kindly Fruits of the Earth: The Development of an Embryo Ecologist* (New Haven, Conn.: Yale Univ. Press, 1979); Ernst Mayr, "How I Became a Darwinian," in *The Evolutionary Synthesis: Perspectives on the Unification of Biology*, ed. Mayr and William Provine (Cambridge, Mass.: Harvard Univ. Press, 1980), pp. 413–423; and George Gaylord Simpson, *Concession to the Improbable: An Unconventional Autobiography* (New Haven, Conn.: Yale Univ. Press, 1978).

[20] Marilyn Ogilvie and Clifford Choquette, "Nettie Marie Stevens (1861–1912): Her Life and Contributions to Cytogenetics," *Proc. Amer. Phil. Soc.*, 1981, *125*:292–311; Stephen Brush, "Nettie M. Stevens and the Discovery of Sex Determination by Chromosomes," *Isis*, 1978, 69:163–172; and Ogilvie, "Alice M. Boring: An American Scientist in China," paper presented to the History of Science Society, Norwalk, Conn., Oct. 1983.

[21] Mary Pickard Winsor, "Louis Agassiz and the Species Question," *Stud. Hist. Biol.*, 1979, *3*:89–117.

[22] Philip Pauly, "G. Stanley Hall and His Successors: A History of the First Half-Century of Psychology at Johns Hopkins University," paper prepared for the G. Stanley Hall Centennial, Johns Hopkins University, 1983; Dennis McCullough, "W. K. Brooks's Role in the History of American Biology," *J. Hist. Biol.*, 1969, *2*:411–438; Keith Benson, "William Keith Brooks (1848–1908): A Case Study in Morphology and the Development of American Biology" (Ph.D. diss., Oregon State Univ., 1979); and Benson, "American Morphology in the Late Nineteenth Century: The Case of the Biology Department of Johns Hopkins University," *J. Hist. Biol.*, forthcoming.

[23] Lincoln C. Blake, "The Concept and Development of Science at the University of Chicago, 1890–1905" (Ph.D. diss., Univ. of Chicago, 1966), esp. Ch. 4 on Charles Otis Whitman and biology.



The Marine Biological Laboratory (MBL) at Woods Hole, Massachusetts. Courtesy of the MBL.

results since Chicago turned out a number of major scientists (including Just) concerned with the organism as a whole.

A thorough study of Henry Fairfield Osborn's role in establishing Columbia University's biology program, which became the home for Morgan's genetics and Wilson's cytology, might likewise illuminate the interaction between institutions and the practice of biology with particular styles. So would a closer look at other university departments and research laboratories, revealing interactions of individuals, problems, methods, and settings.

Marine laboratories—the Marine Biological Laboratory, Friday Harbor, Cold Spring Harbor, the Bermuda Experimental Station, and Scripps—have also played an important part in American biology. Attention has been directed to the MBL, both in Dexter's study of Alpheus Hyatt's and Louis Agassiz's antecedent laboratories and in a conference dedicated to the history of the MBL and the Naples Zoological Station. And Paul Galtsoff and Dean Allard have examined the United States Fish Commission, which was closely tied to the MBL in the early years. Aside from Lillie's limited documentary history of 1944, however, there is no systematic study of later MBL history and the laboratory's very considerable impact on American science. The approaching centennial (in 1988) has already begun to stimulate interest, the MBL has a growing archives to provide material, and administrators and librarians there are welcoming historical interest with unusual enthusiasm and support. Historians of biology should avail themselves of this opportunity. As for other marine laboratories, Keith Benson has traced the early history of the University of Washington's laboratory at Friday Harbor; an early article by Ernst Dornfeld establishes the few available facts about the short-lived but important Allis Lake Laboratory; and materials from the Carnegie Institution's Cold Spring Harbor Laboratory have begun to receive some consideration.[24] A fuller picture of the motivations behind, and works carried on at, these marine laboratories, their antecedents, and other similar research facilities including summer camps will add to our understanding of the setting and constraints on American biological research.

Other institutions, including public and private museums and societies have likewise shaped the science of biology in the United States. Ronald Rainger has begun an examination of the American Museum of Natural History and of Henry Fairfield Osborn's role there. He demonstrates that scientific convictions influenced the public presentation of specimens and that, in turn, the need for public presentation at times influenced the scientific ideas. Charles Coleman Sellars's account *Mr. Peale's Museum* illustrates the earlier desire to collect natural curiosities and to make sense of them. Philip Kopper's beautifully illustrated book on the holdings, though not really the history, of the National Museum of Natural History exemplifies the interest in natural history in our "nation's attic." Jeffrey Stott's study of American zoological parks underlines the American fascination with public lands and the way in which protection supports science. Wardell Pomeroy's study of the Kinsey Institute for Sex Research points to a different sort of natural history work, with its collection of largely American sex histories, of interest to historians of biology. Sally Kohlstedt's examination of the Boston Society of Natural History illustrates the depth of local concern with nature study.[25] Further examples of museums, other public enterprises concerned with natural history or biology, and biological societies abound, providing opportunities for further study and for comparative assessments.

[24] Ralph Dexter, "From Penikese to the Marine Biological Laboratory at Woods Hole—The Role of Agassiz's Students," *Essex Inst. Hist. Coll.*, 1974, *110*:151–161; Dexter, "The Annisquam Seaside Laboratory of Alpheus Hyatt, Predecessor of the Marine Biological Laboratory at Woods Hole, 1880–1886," in *Oceanography: The Past*, ed. Mary Sears and Daniel Merriam (New York: Springer, 1980), pp. 94–100; "The MBL and the Stazione Zoologica: A Century of History," conference at Ischia, Italy, Oct. 1984, with proceedings to appear in *Biological Bulletin*, June 1985; Detlev W. Bronk, "Marine Biological Laboratory: Origins and Patrons," *Science*, 1975, *189*:613–617; Paul Galtsoff, *The Story of the Bureau of Commercial Fisheries Biological Laboratory, Woods Hole, Mass.* (Washington, D.C.: U.S. Dept. of the Interior, 1962); Dean Conrad Allard, Jr., *Spencer Fullerton Baird and the U.S. Fish Commission* (Ph.D. diss, George Washington Univ., 1967; New York: Arno, 1978); Frank Rattray Lillie, *The Woods Hole Marine Biological Laboratory* (Chicago: Univ. Chicago Press, 1944); Keith Benson, "A History of the Laboratory at Friday Harbor" (forthcoming); Ernst J. Dornfeld, "The Allis Lake Laboratory," *Marquette Medical Review*, 1956, *21*:115–144; and James Ebert, article on Cold Spring Harbor and the Carnegie Foundation, *Biological Bulletin*, 1985, forthcoming.

[25] Ronald Rainger, "Fossils for Knowledge and Enlightenment: Vertebrate Paleontology at the American Museum, 1890–1910," paper presented to the History of Science Society, Chicago, Dec. 1984; Charles Coleman Sellars, *Mr. Peale's Museum: Charles Willson Peale and the First Popular Museum of Natural Science and Art* (New York: Norton, 1980); Philip Kopper, *The National Museum of Natural History* (New York: Abrams/Smithsonian, 1982); Jeffrey R. Stott, "The Historical Origins of the Zoological Park in American Thought," *Environmental Review*, 1981, *5*:52–65; Sally Gregory Kohlstedt, "From Learned Society to Public Museum: The Boston Society of Natural History," in *The Organization of Knowledge in Modern America, 1860–1920*, ed. Alexandra Oleson and John Voss (Baltimore: Johns Hopkins Univ. Press, 1979), pp. 386–406; Kohlstedt, "The Nineteenth Century Amateur Tradition: The Case of the Boston Society of Natural History," in *Science and Its Public: The Changing Image*, ed. Gerald Holton and William A. Blanpied (Dordrecht/London: Reidel, 1976), pp. 173–190.

One such comparative assessment comes in Pauly's examination of the relations between medicine and biology around 1900. Those universities with strong medical programs generally failed to establish effective and progressive biology programs in part, Pauly argues, because the required service to medicine drew resources away from active efforts to define and enliven the biological research. This thesis needs further articulation and development but suggests similar comparative questions. The relations between development of biology programs and the availability of strong or weak museums, herbaria, or journals might illuminate how nonintellectual factors have influenced the development of biology. Such factors might also prove to have influenced the ideas of science, as Rainger has shown they did at the American Museum.[26]

In addition, William Haas has raised questions about the differences between American and Chinese attitudes toward botany and taxonomy, indicating that botanists have exchanged materials and visits but generally not approaches in the twentieth century. His study highlights the issue of how biology in the United States is in at least some ways a distinctly American enterprise. It may be that particular techniques or laboratory styles or individual schools have affected the national character of American biology in unique and significant ways. It may also be that there are broader underlying ideological assumptions that influence the national character of science, as Haas suggests.[27]

Other sorts of institutions such as university museums, herbaria, journals, and funding agencies have received little attention. Both Pnina Abir-Am and Robert Kohler have studied the Rockefeller Foundation's approach to molecular biology and thus provide examples of how one foundation influenced biology.[28] Manning has examined funding by the Rockefeller Foundation of Just's biology. Many other questions remain to be explored, and many of these institutions have archival collections and resources of their own awaiting historical study.

DISCIPLINES

Disciplinary studies are enjoying considerable popularity. Rainger's and Stephen Jay Gould's work on the history of paleontology and taxonomy and Toby Appel's study of Jeffries Wyman and evolution return to subjects neglected in the recent rush to understand modern experimental biology. Charlotte Porter's work serves as a reminder of the vast untouched materials in the history of natural history. John C. Greene's admirable survey of American science in the age of Jefferson offers rich chapters on zoology, botany, and related themes. Greene demonstrates that this early and neglected period of American biology deserves attention even though the various American activities in science did not always fall together into a neatly connected story. More specialized studies include Patricia Gossel's examination of the origins of American bacteriology as a scientific discipline; Gossel surprisingly reveals that American bacteriology initially found its place as a part of botany. And Michael Sokal has shown that psychology deserves attention as a field closely related to biology in the early years of this century.[29] Oceanography, agriculture, ecology, embryology, and evolutionary biology also have begun to receive more careful attention.

Susan Schlee's studies of oceanography are a case in point. Though she does not define oceanography or worry explicitly about what is included and what is not, she presents a useful descriptive history of studies, including American studies, of the sea. Government patronage played a critical role in setting up oceanographic ventures, so Schlee describes details of funding and political hopes, along with the realities of various expeditions and laboratories. Schlee's accounts are both well written and full of suggestions for deeper and more analytical studies. Her history of the *Atlantis* exemplifies one creative direction for further work, for it provides essentially a biography of one important American research vessel. A collection of historical papers originally presented at the Woods Hole Oceanographic Institution suggests other approaches to the history of oceanography as different authors tackle a variety of problems.[30]

Agriculture maintains close relations with biology in some respects, but few historians of science have examined these connections, with the notable exceptions of Margaret Rossiter, in several different contexts, and Charles Rosenberg, in articles. Rossiter's book-length study of scientific training, agricultural laboratories, and educational institutions from 1840 to 1880 documents the way in which Americans embraced the important science of agricultural chemistry. Her more recent essay serves as a tantalizing introduction to the decades 1860–1920, but no one has seriously studied later periods. As Rossiter points out in a separate and useful bibliography, histories of agriculture have tended to stick with the ABCs (Johnny Appleseed, Luther Burbank, and George Washington Carver), even though many biological contributions began or continued in agricultural settings—for example, studies of sex production and sexual reproduction.[31]

[26] Philip Pauly, "The Appearance of Academic Biology in Late Nineteenth Century America," *J. Hist. Biol.*, 1984, *17*:369–397; Rainger, "Fossils for Knowledge and Enlightenment" (cit. n. 25).

[27] William Haas, "Botany in Republican China: The Leading Role of Taxonomy," paper presented at the Rockefeller Institution.

[28] Pnina Abir-Am, "The Discourse of Physical Power and Biological Knowledge in the 1930s: A Reappraisal of the Rockefeller Foundation's 'Policy' in Molecular Biology," *Social Studies of Science*, 1982, *12*:341–382; and Robert E. Kohler, "Warren Weaver and the Rockefeller Foundation Program in Molecular Biology: A Case Study in the Management of Science," in *The Sciences in the American Context: New Perspectives*, ed. Nathan Reingold (Washington, D.C.: Smithsonian Institution Press, 1979), pp. 249–293.

[29] Ronald Rainger, "Paleontology and Philosophy: A Critique," *J. Hist. Biol.*, forthcoming; Rainger, "The Understanding of the Fossil Past: Paleontology and Evolution Theory, 1850–1910" (Ph.D. diss., Indiana Univ., 1982); Stephen Jay Gould, *Ontogeny and Phylogeny* (Cambridge, Mass.: Harvard Univ. Press, 1977); Toby Appel, "A Little Too Modest: Jeffries Wyman, Philosophical Anatomy and Evolution," paper presented to the History of Science Society, Norwalk, Conn., Oct. 1983; Charlotte Porter, "The Concussion of Revolution: Publications and Reform at the Early Academy of Natural Sciences, Philadelphia, 1812–1842," *J. Hist. Biol.*, 1979, *12*:273–292; Porter, "The Excursive Naturalists or the Development of American Taxonomy at the Philadelphia Academy of Natural Sciences, 1812–1842" (Ph.D. diss., Harvard Univ., 1976); John C. Greene, *American Science in the Age of Jefferson* (Ames: Univ. Iowa Press, 1984); Patricia Gossel, "The Species Problem in Bacteriology: A Technical and Diagnostic Dilemma," paper presented to the Joint Atlantic Seminar for the History of Biology, Washington, D.C., Apr. 1984; Michael Sokal, ed., *An Education in Psychology: James McKeen Cattell's Journal and Letters from Germany and England, 1880–1888* (Cambridge, Mass.: MIT Press, 1981); and Sokal and Patrice Rafail, comps., *A Guide to Manuscript Collections in the History of Psychology and Related Areas* (Millwood, N.Y.: Kraus International, 1982).

[30] Susan Schlee, *The Edge of an Unfamiliar World: A History of Oceanography* (New York: Dutton, 1973); Schlee, *On Almost Any Wind: The Saga of the Oceanographical Vessel* Atlantis (Ithaca, N.Y.: Cornell Univ. Press, 1978); and Sears and Merriam, eds. *Oceanography: The Past.*

[31] Margaret Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840–1880* (New Haven, Conn.: Yale Univ. Press, 1975); Rossiter, "The Organization of the Agricultural Sciences," in *Organization of Knowledge*, ed. Oleson and Voss (cit. n. 25), pp. 211–248;

Trained as a sociologist, Rachel Volberg has examined networks of communication that surrounded the development of a professional discipline of botany in the United States from 1880 to 1920. She argues that as botany became professionalized, researchers eliminated problems and disciplines within botany not amenable to experimentation. Volberg stresses the nonintellectual and nontheoretical convictions that have dictated what was considered "acceptable" science. Although Volberg emphasizes details about the way science works that may seem odd or extraneous to the more theoretically inclined, this work is an important examination of botany's relations to agriculture, funding agencies, institutions, and other disciplines. The historian of science can gain valuable insight about the role of communication networks and shared assumptions from this and other sociological studies.[32]

Ecology has begun to receive a great deal of attention recently, as demonstrated by the range of studies Frank Egerton discusses in a two-part article. The first reviews the field to date and is not strictly limited to ecology in the United States. The second part surveys the history of applied ecology in North America. Researchers are focusing on such questions as what ecology is and how it emerged and has developed in relation to other biological disciplines. Donald Worster's more popular treatment, Ronald Tobey's look at grasslands ecology, Sharon Kingsland's study of laboratory and experimental work, Eugene Cittadino's discussion of professionalization in botany in the United States, James Collins's work on evolutionary ecology, William Coleman's work on ecology prior to the evolutionary synthesis, and Joel Hagen's examination of plant ecology and taxonomy, among others, serve to illustrate this healthy and productive diversity of questions and approaches.[33]

Embryology and genetics have also attracted increasing interest. For example, Jeffrey Werdinger's doctoral dissertation studying embryology at the MBL demonstrates the importance of the community there in facilitating the exchange of ideas. At a time when experimental embryology was changing rapidly, this exchange proved central to the emergence of the field and its separation from the study of heredity, to the extent that such a separation really occurred. Scott Gilbert's analysis of Morgan's embryological work also examines the emergence of genetics and embryology as distinct disciplines, as does a recent paper by Garland Allen. Jan Sapp is exploring lines of biological research in the United States and France that continued to emphasize development, with his study of work on cytoplasmic inheritance. And Jane Maienschein's survey of studies of sex determination points to an area lying between embryology and genetics, an area that has begun to attract increasing historical attention from biologists as well. Numerous studies of the rise of the field of genetics have appeared or are in preparation, including Horace Judson's masterfully written *Eighth Day of Creation* and Kevles's survey of genetics in the United States and Britain.[34]

Studies of evolutionary biology include several examinations of the relationship between biology and religion, with attention to issues of creationism. Others focusing more directly on biological work, particularly in the nineteenth century, include Cynthia Russett's study of the reception of Darwinism in the United States and essays by Michele Aldrich and Edward Pfeifer in Thomas Glick's *Comparative Reception of Darwinism*. Peter Bowler has extended the discussion of evolutionary ideas after Darwin. Bowler's *Eclipse of Darwinism*, for example, classifies such Americans as Louis Agassiz, Edward Drinker Cope, Henry Fairfield Osborn, and William Berryman Scott as anti-Darwinians and discusses the various versions of anti-Darwinism. Ernst Mayr and William Provine have extended the discussion to more recent evolutionary biologists with the *Evolutionary Synthesis*.[35]

Among the subjects closely related to history of biology but not traditionally considered part of biology is the environment, the subject of several studies. Stephen Pyne's *Fire in America* provides an excellent and imaginative definition of a problem in this area, examining approaches to forest and fire management, bureaucratic control, and factors very closely related to studies of botany and agriculture. Roderick Nash, Thomas Dunlap, and Michael Cohen have also examined issues of conservation and environment in ways that illuminate American concerns with organic nature.[36]

Rossiter, comp., "A List of References for the History of Agricultural Science in America" (University of California at Davis Agricultural History Center, 1980); and Charles Rosenberg, "Rationalization and Reality in the Shaping of American Agricultural Research, 1875–1914," *Soc. Stud. Sci.*, 1977, 7:401–422; see also Rosenberg, *No Other Gods: On Science and American Social Thought* (Baltimore: Johns Hopkins Univ. Press, 1976), Chs. 8–12.

[32] Rachel Volberg, "Constraints and Commitments in the Development of American Biology, 1880–1920" (Ph.D. diss., Univ. California at San Francisco, 1983).

[33] Frank N. Egerton, "The History of Ecology: Part I. Achievements and Opportunities," *J. Hist. Biol.*, 1983, *16*:259–310; "Part II. Applied Ecology in North America," *ibid.*, forthcoming; Ronald C. Tobey, *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895–1955* (Berkeley/Los Angeles: Univ. California Press, 1981); Sharon Kingsland, "The Refractory Model: The Logistic Curve and the History of Population Ecology," *Quart. Rev. Biol.*, 1982, *57*:29–52; Kingsland, "Modelling Nature: Theoretical and Experimental Approaches to Population Ecology, 1920–1950" (Ph.D. diss., Univ. Toronto, 1981); Eugene Cittadino, "Ecology and the Professionalization of Botany in America, 1890–1905," *Stud. Hist. Biol.*, 1980, *4*:171–198; James Collins, "Evolutionary Ecology and the Changing Role of Natural Selection in Ecological Theory," paper presented to the conference on history, philosophy, and biology, Denison University, July 1983; William Coleman, "Evolution into Ecology," paper presented at the conference "Reflections on Ecology and Evolutionary Biology," Arizona State University, March 1985; Joel Hagen, "Experimental Taxonomy, 1930–1950: The Impact of Cytology, Ecology, and Genetics on Ideas of Biological Classification" (Ph.D. diss., Oregon State Univ., 1982); and Hagen, "Experimentalists and Naturalists in Twentieth-Century Botany: Experimental Taxonomy, 1920–1950," *J. Hist. Biol.*, 1984, *17*:249–270.

[34] Jeffrey Werdinger, "Embryology at Woods Hole: The Emergence of a New American Biology" (Ph.D. diss., Indiana Univ., 1980); Gilbert, "Embryological Origins of Genetics" (cit. n. 6); Garland Allen, "T. H. Morgan and the Split Between Embryology and Genetics, 1910–1926," paper presented to the British Society for Developmental Biology, Nottingham, 1983; Jan Sapp, "Cytoplasmic Inheritance and the Struggle for Authority in the Field of Heredity, 1891–1981" (Ph.D. diss., Univ. Montreal, 1984); Sapp, "The Field of Heredity and the Struggle for Authority: Some New Perspectives on the Rise of Genetics," *J. Hist. Biol.*, 1983, *16*:311–342; Jane Maienschein, "What Determines Sex? A Study of Converging Approaches, 1880–1916," *Isis*, 1984, *76*:457–480; and Horace Judson, *The Eighth Day of Creation: Makers of the Revolution in Biology* (New York: Simon & Schuster, 1979); Daniel J. Kevles, "Genetics in the United States and Great Britain, 1890–1930: A Review with Speculations," in *Biology, Medicine, and Society, 1840–1940* (Cambridge: Cambridge Univ. Press, 1981), pp. 193–215.

[35] On creationism see, e.g., Dorothy Nelkin, *The Creation Controversy: Science or Scripture in the Schools* (New York: Norton, 1982); see also Cynthia Russett, *Darwin in America: The Intellectual Response, 1865–1912* (San Francisco: Freeman, 1976); Michele Aldrich, "United States: Bibliographic Essay," in *The Comparative Reception of Darwinism*, ed. Thomas F. Glick (Austin: Univ. Texas Press, 1974), pp. 207–226; Edward Pfeifer, "The United States," *ibid.*, pp. 168–206; Pfeifer, "The Genesis of American Neo-Lamarckism," *Isis*, 1965, *56*:156–167; Peter Bowler, *The Eclipse of Darwinism: Anti-Darwinian Evolution Theories in the Decade around 1900* (Baltimore: Johns Hopkins Univ. Press, 1983); and Richard Burkhardt, "Lamarckism in Britain and the United States," in *Evolutionary Synthesis*, ed. Mayr and Provine (cit. n. 18).

[36] Stephen Pyne, *Fire in America: A Cultural History of Wildland and Rural Fire* (Princeton, N.J.:

Despite the growing number of studies on subareas of biology and despite the expansion into related concerns, relatively few scholars have moved to later or to more technical disciplines, such as biochemistry or molecular biology. Few historians of science have pursued philosophically informed questions about how science has developed in the twentieth century, questions about the nature of biology or the ways in which biology has changed, for example. Further, only a handful have examined the way in which specialties arose because of, or with the support of, institutional factors. The diversity of studies to date makes the history of biology in America a healthy and robust field, but a further abundance of problems, questions, and approaches obviously remains to be explored as well.

CONCLUSION

On the whole, the historical study of biology in the United States is a robust, exciting field. While historians concerned with recent developments in particular will need to update their technical knowledge, many other historians would profit from a more sophisticated understanding of biology and what it is. Moreover, some will find it useful to explore philosophical and theoretical issues, while others should acquire more sophisticated tools of social analysis in order to assess the impact of factors external to scientific ideas. Others will begin to explore the way in which or extent to which biology in America has also been a distinctly American biology. They will begin to answer those questions about how to define the field of history of American biology and how best to approach it. As historians of biology investigate new issues, they will begin to divide up their problems in new ways, yielding novel perspectives. The continued willingness to accept diverse approaches should allow the history of biology in America to remain a particularly lively, productive, and inviting field of study.

Princeton Univ. Press, 1982); Roderick Nash, *The American Environment: Readings in the History of Conservation* (Reading, Mass.: Addison-Wesley, 1968); Nash, *Wilderness and the American Mind* (3rd. ed.: New Haven, Conn.: Yale Univ. Press, 1982); Thomas Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton, N.J.: Princeton Univ. Press, 1981); and Michael P. Cohen, *The Pathless Way: John Muir and American Wilderness* (Madison: Univ. Wisconsin Press, 1984).