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dent quarters; a woman's dormitory was constructed in 1915, and some cottages were converted to student use in the 1920s, probably as local rooming houses became private homes.

66. Manning, *Black Apollo*, pp. 67–114; Jacques Loeb to Simon Flexner, draft on Flexner to Loeb, 15 January 1923, Box 4, Loeb Papers.

67. C. R. Crane, in "MBL Dedication Exercises," p. 271; Faught, *Falmouth Massachusetts*, pp. 27, 176–177; problems during the interwar years were noted in Luther J. Carter, "Woods Hole: Summer Mecca for Marine Biology," *Sci.*, 1967, *157*: 1288–1292.

68. National Academy of Sciences, *Annual Report*, 1918, p. 108, 1919, pp. 100–101; Diana E. Long, "Physiological Identity of American Sex Researchers between the two World Wars," in Geison, *Physiology in the American Context*, pp. 263–278; Robert E. Kohler, *From Medical Chemistry to Biochemistry* (Cambridge: Cambridge University Press, 1982), pp. 307–321.

69. L.J. Henderson, *The Order of Nature* (Cambridge, Mass.: Harvard University Press, 1917); F. R. Lillie, "The Mechanistic View of Vital Phenomena"; W. E. Ritter, *The Unity of the Organism*, 2 vols. (Boston: R. G. Badger, 1919); W. M. Wheeler, *Emergent Evolution and the Development of Societies* (New York: Norton, 1928). An intriguing instance of unconscious self-reflexiveness is the holist Lewis Thomas's use of Wheeler's concept of the superorganism in *Lives of a Cell* (New York: Viking Press, 1974), pp. 58–63, to describe the MBL. For a minority viewpoint during these discussions, see E. B. Wilson, *The Physical Basis of Life* (New Haven: Yale University Press, 1923).

70. Most major American theorists of community between 1890 and 1940, including George Herbert Mead, John Dewey, Robert MacIver, Robert Park, and Robert Redfield, worked at either the University of Chicago or Columbia, and were aware of both the writings and the lives of their biological colleagues. See, e.g., Martin Bulmer, *The Chicago School of Sociology* (Chicago: University of Chicago Press, 1984), pp. 129–150.

Jane Maienschein

5 Whitman at Chicago: Establishing a Chicago Style of Biology?

In the 1860s or early 1870s, an American interested in a professional career in biology would likely have been drawn to Harvard University, to study botany with Asa Gray or zoology with Louis Agassiz, or possibly to Yale. After 1876, such an American would have found the new Johns Hopkins University particularly attractive, with its much-publicized emphasis on the medically related biological and physical sciences. Other alternatives existed by this time, including a visit to European laboratories, but male students interested in a program in life sciences would nonetheless probably have found Johns Hopkins the most exciting, while after 1884 women might well have migrated to Bryn Mawr College. After 1890, our motivated student would have found yet other new opportunities, at research-oriented Clark University (after 1889) or at Columbia University's College of Pure Sciences (after 1891), for example. Each of these institutions offered programs of study in the biological sciences, although not all were explicitly labeled as "biology." Each produced a collection of outstanding students. The University of Chicago then entered the competition in a major way.

The University of Chicago was legally established and construction began in 1892, as Chicago planned its great Columbian Exhibition for the next year. Indeed, the University virtually backed onto the fairgrounds, so that a ride on the Ferris wheel provided a fine view of the developing university campus. Debates had surrounded the construction of both the Fair and the University, demonstrating that what some saw as progressive, others regarded as retrogressive. For example, architect Louis Sullivan lamented that with the Fair, "architecture died in the land of the free and the home of the brave—in a land declaring its democracy, inventiveness, unique daring, enterprise, and progress. Thus ever works the pallid academic mind, denying the real, exalting the fictitious and false. The damage wrought by the World's Fair will last for half a century from its date, if not longer."[1] According to this view, the university

followed with its deplorable "Collegiate Gothic" buildings of "City Gray." Yet others found the Fair, the University buildings, and art in Chicago exciting. Sculptor Augustus Saint-Gaudens, for example, saw things much more positively, asking about the Exhibition preparations, "Do you realize that this is the greatest gathering of artists since the fifteenth century?"[2] Out of this excitement and disagreement came what was called a "Chicago style" of architecture.

More recently it has become unfashionable in some circles to speak of styles in architecture, and perhaps rightfully so. Yet there is some level of generalization that helps clarify patterns of historical development, unifying study of individuals and of institutions, while also considering the sort of work done. For science, the sociologist/historians of science at the Tremont Research Institute have identified what they label as the "style of work."[3] This sense of style concerns what scientists ask, what problems they consider worth solving, what techniques they employ, what approaches they adopt, what organisms they choose. In short, what work do they do and how do they do it? If there is a definable style of work for a particular set of researchers, then they should share many of the ways of working with others in their group but not as many with workers outside. Yet the style need not be as localized as a research institution or research school might be. Closer in some ways to a research tradition, a style is a subset of such units, influenced also by local setting, individuals, and organization and by non-rational factors. If a Chicago style of biology exists in this sense, we should be able to identify research work that, at least with a high probability, has its origins in Chicago rather than somewhere else.

I am not fully convinced that this sense of "style" is the best possible unit of historical study. Yet the phenomenon did occur that Charles Otis Whitman and others with similar convictions about biological work created a community at Chicago that produced students who pursued work of just the same sort and in the same way as their advisors. Explaining that phenomenon calls for studying at some different level of analysis in science, more than simply a consideration of either the individuals or the institution involved, and perhaps the style of work is the appropriate place to look. It cannot be coincidental that researchers such as Whitman, Frank Lillie, William Morton Wheeler, Charles Manning Child, Ernest Everett Just, and others of similar scientific approach all gathered in Chicago. Chicago was extremely influential in biology and had considerable glamour and prestige. It produced results that people associated with Chicago. Perhaps that particular character did lie in the work done, by individuals with a particular vision of biology, within a peculiarly promising institutional setting.

This paper provides a preliminary exploration of a Chicago style of biology by considering the origins of the University of Chicago as an institution, biology there, and especially the first chairman of biology, Charles Otis Whitman, who had a driving sense of what biology should be and an autocratic approach to putting his vision into effect. To a remarkable extent, zoology in particular followed Whitman's direction. This paper therefore concentrates on Whitman's role as director and exemplar for Chicago biology.

The story told here suggests that there was a characteristic Chicago style of biology initiated by Whitman, which extended beyond Whitman. The full argument and evidence for that broader claim remains beyond the scope of this particular paper and tantalizingly suggests a much larger program of study which would extend to all subfields of biology at Chicago. In addition, any claim that a Chicago style of biology was unique would have to compare work there with work elsewhere. In this paper I want to establish what happened at Chicago and to offer preliminary suggestions for interpreting its significance.

In the Beginning

An early effort to establish a Baptist University of Chicago failed for financial reasons.[4] After foreclosure on the building loans brought an end to the initial effort, a small group of prominent Chicago Baptists determined in 1886 to try once more, this time in a new location and with a sound financial footing. They acquired land and sought outside funding, hoping to establish a "western Yale." Loyal Baptist supporter Thomas Wakefield Goodspeed, who spearheaded the project, sought the support of that wealthy Baptist John D. Rockefeller.[5]

In effect, Rockefeller made the new University of Chicago possible. After months of negotiation and careful deliberation, Rockefeller was persuaded to give $600,000 by the positive reports from his assistant Frederick T. Gates and by conversations with sympathetic project supporter William Rainey Harper. He thereby founded a Baptist college, rather than a more ambitious research university, with the condition that his contribution be matched by $400,000 from local Chicago supporters. By September 1890, those supporters had pledged more than the requisite amount, and the new University of Chicago was incorporated on 10 September. Shortly thereafter, Goodspeed and others sought to lure Harper away from his position as biblical scholar at Yale University to accept the presidency of the new western university. But Harper worried both that the job would force him to abandon the biblical study he loved and that the $1,000,000 from Rockefeller and the Chicago supporters would not prove sufficient to build a first-class institution. Evidently responding to this concern Rockefeller provided a second million dollars, of which part was to support a seminary and $800,000 was designated for graduate support for the University. Harper accepted the presidency in February 1891, despite being pressured to remain at Yale.[6]

Harper then settled down to the difficult task of securing the best faculty, a

task exacerbated by recruitment efforts at Columbia University and Stanford University at the same time.[7] With the goal of securing a strong arts and science faculty of established scholars and surrendering, at least for the moment, hopes for a technical school as well, Harper began to make appointments.

In the biological sciences, he first recruited Clarence L. Herrick, a biologist at the University of Cincinnati who had been at Denison University where Harper had earlier spent some time. This hiring ultimately proved problematic.[8] Recall that Harper was a Biblical scholar, not a scientist. Recall also that he was originally hiring for a Baptist college rather than for a major research university. In his first appointment in science, he looked to a midwesterner. Herrick, born in Minnesota and educated there and in Germany, did not then have a Ph.D. (although he did complete one later). After a period at Denison, he went to the University of Cincinnati in 1889 as chair in biology. With his special interest in psychobiology, or that borderland between physiology and psychology and even philosophy, Herrick could offer Chicago a modern and popular area of study. He would also bring his *Journal of Experimental Neurology*. For a Baptist school supported by religious interests, the appointment of someone who studied the biology of mind made sense; in the bargain, Herrick was a good Baptist. After some negotiation about his precise role and about financial details, Harper formally offered Herrick a position, evidently as Professor of Comparative Psychology, in June 1891.[9]

In his initial proposals for the department at Chicago, Herrick had stressed the importance of undergraduate teaching in particular. Herrick clearly took his appointment as evidence that Harper was at least favorably disposed toward his plans, and there is even some evidence that Harper may have initially considered Herrick for the chairmanship for the biology department.[10] It seems that Herrick expected to have charge of at least the anatomy and physiology sections.[11] On the basis of what he felt was a strong commitment to his ideas as well as a firm offer from Harper, Herrick left his position at Cincinnati and set off for Europe for a year. Yet Harper had actually refrained from making any concrete commitments beyond the offer of a faculty appointment. Harper had even informed Herrick in May, and hence before his job offer, that he had also entered into negotiation with zoologist Charles Otis Whitman of Clark University.

In fact, Harper had corresponded with Whitman about the development of biology at Chicago and had received rather different suggestions from those Herrick offered. Whitman stressed the importance of graduate education and of both faculty and student research. In December 1891, Whitman wrote to Harper that he was "ready to consider the offer" that Harper had made, presumably for Whitman to chair the biological sciences at Chicago, if Harper could promise him at least $50,000 income for biology each year and would give him control. He thought that Chicago offered "the opportunity to start an organization in one of the most advantageous regions of the entire country."

He then advertised his qualifications for the job, presumably in part to convince Harper to work harder to obtain what Whitman requested. As Whitman pointed out, he would bring with him the leading American zoological journal and control of the only national marine laboratory, both considerable attractions. Whitman also hoped to add an inland lake laboratory sponsored by the University of Chicago to the collection. As to organization, he would set up zoology, botany, paleontology, and physiology as the four divisions of the biological sciences, with anthropology to follow soon after. Whitman felt certain that others from Clark would join the move if Harper invited them.[12]

When it became clear that Chicago could become a full-scale university rather than a more modest Baptist college, thanks to a generous donation after 1891 from the estate of William B. Ogden to build scientific laboratories, Harper began to consider seriously Whitman's suggestions for first-rate biological research.[13] Harper turned increasingly to Whitman and to Clark University for inspiration and for quality material with which to build his faculty. In fact, the serious problems at Clark in 1891–92 probably gave Harper his first major successes in recruiting in the sciences.

Clark University, like the Johns Hopkins and the University of Chicago, had been established with grand hopes for providing the best in education based on a strong scientific and research-oriented foundation. Yet Clark's benefactor, Jonas Gilman Clark, turned out to be somewhat less generous in his financial support of the new institution than some, at least, had expected and less generous than was actually needed. Thus President Granville Stanley Hall, with a Ph.D. and teaching experience in experimental psychology at Johns Hopkins, had high ambitions and great enthusiasm but also, inevitably, problems. In this unique institution designed specifically to offer quality graduate education, Hall had gathered an impressive group of faculty and students in the very first year, 1889.

Financial and ideological differences surfaced quickly, however, so that Whitman seriously considered an offer to go to Stanford in 1891. He decided to stay after Hall promised to improve the situation at Clark.[14] But by the third year, Whitman and most of the rest of the faculty recognized deeper trouble. After several unsatisfactory meetings in the fall of 1891, in January 1892 a majority of the full Clark teaching staff signed a vote of no-confidence in their president and formally resigned their positions in protest. They felt that, because various promises had been broken, they could no longer trust their chief administrator.[15] Hall worked desperately to keep them, and they did withdraw their resignations at least temporarily. Yet, as one historian remarked, Chicago offered powerful attractions, for "I think we may be rather sure that even if they had been on the best possible terms with Dr. Hall and the Board few of them could have refused the opportunity to go into new laboratories, in beautiful buildings fitted with every possible convenience, with much more to spend for equipment, books, laboratory assistants, etc.; with the background

of a big city containing rare libraries, medical schools and other facilities that Clark could never duplicate, and with no Founder dropping in every day or so."[16] At least such accouterments are what Harper promised.

Yet Whitman had no desire to jump from one problem at Clark to another at Chicago. He was an excellent and ambitious administrator and sought to clarify many of the numerous and superficially tedious details that he recognized as important. Although he had resolved that the Clark situation was intolerable, he also worried about the situation at Chicago. Correspondence between Whitman's friend, anatomist Franklin Paine Mall, and Harper reveals the critical issues. As early as 27 January 1892, only a week after the no-confidence meeting at Clark, Mall reported to Harper that

> I have also constantly had my fears that the biological scheme might not develop. The amount he [Whitman] suggests is not great if all the departments are included; the physiological department alone at Columbia has a salary list of 15,000 and at Berlin over 50,000. Yet with these things clearly in view, I have constantly urged Prof. Whitman, and his enthusiasm has most of the time been the highest. When you wrote to him last he felt a little downhearted but the idea of making a biological department with various branches (but not full departments) represented seemed first to me and then to him a way out of the difficulty. Now I feel more hopeful and he tells me that he has written a hopeful letter to you.
>
> On account of much freedom here, in spite of our trouble (confidential), we cling to our ideals. You know of Whitman's organizing abilities. I may add that his students idolize him. —I yet believe that if the ideals which biologists prize so much are again plainly laid before him that he will consider the place most favorably.[17]

In March, Whitman expressed noticeably greater enthusiasm in a letter to Harper. He suggested that, although Hall had asked him to withhold his final decision, he remained quite interested in Chicago. In fact, he would like to take a colleague or two with him if he went. Clearly he knew by then of the Ogden gift and the resulting improved prospects for a biology building. With assurances that a new and modern biological laboratory would be forthcoming, he explained that he could surely decide in favor of Chicago. Yet he remained cautious.[18]

By 7 April, 1892, the situation had become more heated and letters were flying. Mall expressed fears, perhaps calculated to push Harper toward committing his support to Whitman, that Whitman was giving up on Chicago. Chicago offered nothing more than a duplication of what Clark had already given, he pointed out. "Now," he worried, "I believe that nothing short of a laboratory or its absolute assurance within the near future will induce him to accept." Hall wanted to hold onto his faculty members, and they found it difficult to leave. Also, Whitman was a skilled negotiator determined to get the resources he thought necessary to pursue first-rate biological research. As a result of Whitman's requests, as well as Mall's, and made possible by the increased availability of funds for the sciences from the Ogden gift, Harper did promise a laboratory.

Whitman expressed his enthusiasm for Chicago once more in a letter to Harper on 7 April, while once again urging that "the laboratory is simply indispensable." Finally, on 9 April, Mall wrote to Harper that Whitman had, after several hours of arguing and despite all efforts to keep him at Clark, consented to accept Chicago's offer.[19] Harper arrived on the Clark campus eight days later and conducted his famous and brilliantly successful "raid."[20] Meeting at Whitman's house with a majority of Clark's teaching staff, from fellows to instructors to full faculty members, Harper made them an offer that many eventually accepted. Approximately two-thirds of the entire faculty and seventy percent of the students left Clark in 1892, about half to Chicago.[21] Hall reported later that Harper even went so far as to try to persuade him to join the "act of wreckage," but that Hall naturally declined.[22] Of the sixteen biologists at Clark in 1891–92, Harper reportedly arranged to take all but four to Chicago, although a few later accepted offers elsewhere. Leaders among these new recruits from Clark included Whitman, of course, as head of biology and zoology, Mall in anatomy, Henry H. Donaldson in neurology, and Charles A. Strong in psychology.

Herrick no longer would hold primacy even in his own area of psychobiology, a hegemony that he thought Harper had guaranteed him from the beginning. On learning of the new appointments already in effect, about which he had not been consulted, Herrick was evidently furious and resigned his professorship before ever really entering it. He complained of Harper's lack of good faith. Although it may be that Harper exercised imperfect tact in the situation, Storr, Blake, and the archival records all show that, contrary to Herrick's belief, Harper did *not* mislead Herrick.[23] Harper had perhaps alienated Herrick and left him embittered as well as unemployed, but Whitman's version of biology at Chicago had quite reasonably prevailed in the new environment of improved resources and research objectives.[24] Harper had, in fact, obtained a real bargain with the Clark staff, which far surpassed anything that Herrick had to offer.

Whitman at Chicago

When Whitman moved to Chicago, he took with him George Baur, Charles Lawrence Bristol, Henry Herbert Donaldson, Edwin O. Jordan, Frank Rattray Lillie, Franklin Paine Mall, Albert Davis Mead, Charles Augustus Strong (in psychology), Shosaburo Watase, and William Morton Wheeler. Physiologist Jacques Loeb joined the group soon after.

In addition to the faculty, Whitman also took his own ideas about what biology should be like and how it should be organized. He had begun to set

those ideas forth publicly in 1887 with an article considering "Biological Instruction in the Universities."[25] At that time, Whitman was director of the Allis Lake Laboratory near Milwaukee, Wisconsin, following a year as professor of zoology at the Imperial University of Tokyo and two years as assistant in zoology at Harvard. The variety of those jobs, with their several leadership and subordinate roles, against the background of Whitman's graduate work in Germany with Rudolf Leuckart, gave Whitman comparative perspectives from which to reflect on what biology should be like.[26]

At the annual meeting of the American Society of Naturalists in 1886, he had also presented his views on biological instruction. There, Whitman had been stimulated to respond to suggestions that botanist William Gilson Farlow had made the previous year. Farlow had maintained that a university student must be treated, in effect, as a schoolboy, subject to lectures and rote learning "since his capacity for observing and investigating natural objects has been blunted by a one-sided course of instruction at school."[27] Although Whitman agreed with Farlow that observation and investigation were important, he responded that he had greater confidence in the abilities of able students to conduct individual research. Thus, for Whitman, prospective biologists should not be treated as schoolboys but should be put to work doing research.

Although he offered nothing radically new or controversial, Whitman insisted firmly that Americans should follow the successful German model wherein students engaged in active research and began to specialize at an early stage. Biology could not advance with mere lectures and without direct participation. Nor could biology advance if each biologist attempted to cover the entire field. Such a generalist approach reflected an archaic Linnaean attempt to encompass the entire "Systema Naturae" at once. Whitman acknowledged that, regrettably, most Americans calling themselves biologists operated on such hindsight rather than foresight. He believed that

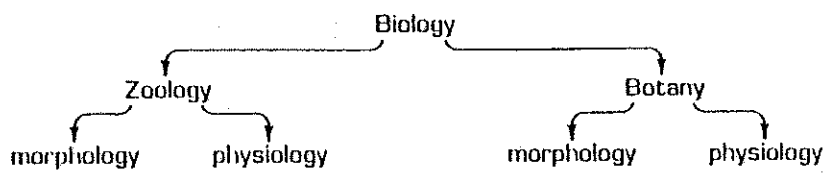
> argument will never dislodge them; they can be reached only through the leavening influence of high examples. A single biological department organized on a basis broad enough to represent every important branch at its best, and provided with the means necessary to the freest exercise of its higher functions, would furnish just the example we stand in need of. It is clear enough where we ought to look for such examples, but it is not so clear where or when we shall find them. We have often heard of the 'coming university,' but still it comes not. Men and money are all that is required to create such a department, and the country has both. We wait only for the rare conjunction of wisdom, will, and means for the realization of the long-postponed expectation.[28]

Let Americans build a system of specialized researchers, with biology including the areas of botany, zoology, physiology, anatomy, and pathology, and with a range of researchers of different ranks within each area.

In 1890, Whitman had his chance to effect his proposals when Clark University promised to provide the necessary "men and money," with Whitman as head of the new biology department there. In his role at Clark and in his capacity as head of the Marine Biological Laboratory (MBL) at Woods Hole, Massachusetts (since 1888), Whitman continued to preach his missionary message of specialization in the biological sciences. But he now explicitly called for organization and cooperation among the specializing researchers.[29] That call he put into effect at the MBL and at Clark. Yet, as we have seen, the Clark experiment did not succeed in graduate biology, at least, and the MBL remained essentially a summer station that could not serve as an example for all of American biological education. The great example would have to be built at Chicago if Whitman was to play the part he sought.

In considering plans for Chicago, Whitman endorsed his earlier view that biology ought to be divided into separate institutes or departments, following the German model. Each of these would then cooperate with the others as a part of a coordinated biological sciences program. Thus, Whitman saw biology as an integrated organic unity with specialized parts and not just as the arithmetic sum of different subdisciplines.[30] In a letter of December 1891, Whitman expressed his enthusiasm for the "new era in the Biology of this country" and his conviction that zoology, botany, paleontology, and physiology should be the four separate departments with which Chicago would begin, with anthropology to follow shortly. Yet the same letter endorsed the selection of Franklin Paine Mall as head of anatomy, so presumably he intended anatomy to be included as one of the specialties as well.[31]

In another letter written after he had accepted Chicago's offer, Whitman expressed his vision for organization more visually as follows:



The zoological morphology side was divided further into zoology, anatomy, histology, neurology, paleontology, and pathology, he contended, with anthropology, cellular biology, and experimental biology to follow. Zoological physiology was divided into human, general, and chemical physiology, along with hygiene and psychology. Botany he did not discuss in as much detail, because he felt that one botanical institute could cover all the important work. Clearly, then, Whitman saw a broad set of biological sciences, with separate organizational and research units under the inclusive rubric of biology.

Actually, Whitman seems to have experienced some ambivalence or lack of clarity in these early efforts to define biology. Whitman seems to have had trouble deciding between a taxonomic organization, as suggested by his diagram, or the more functionally oriented classification of departments listed earlier. Clearly, he wanted to stress the value of separate, independent units of organization that worked together to constitute biology. As to exactly how that was to happen, Whitman initially remained indecisive. His sense of biology was to be inclusive rather than exclusive and open rather than tightly limited. But, again, the specialty units of the biological whole should retain their autonomy and should have definition, as cells do within an organic body.

Following the German ideal of research as he saw it, Whitman believed that at the institutional level these units should exist as administratively separate departments.[32] Harper did not. Harper evidently decided that, at least for the first year, biology would remain as one department, with Whitman as head and with division to come later. Finally, as Mall reported to Harper, Whitman agreed to one initial department with various branches, because several independent departments would have been too expensive.[33] In the second year, biology did divide into separate, though coordinated, departments of zoology, anatomy, physiology, neurology, and paleontology. At that time, Whitman became head of the biological division and of the department of zoology, positions that he retained until his death in 1910.[34] After receiving full departmental status, the several departments began to branch off in various ways so that each became more or less autonomous, despite Whitman's initial calls for strong coordination. To understand the full story of biology at Chicago after the first year, then, we would have to look at the evolution of each of the separate units.[35] Instead of pursuing that study here, I propose in this preliminary effort to concentrate on Whitman and the zoology program, with consideration of those departments most closely allied with zoology. The driving questions are: did Whitman manage to provide an example of the new biology as he had hoped to do; and what was the work like?

Whitman in Charge

As the sober and pious Yankee that one biographer saw, Whitman exhibited a composite of stubbornness and commitment—or what some would call pigheadedness—to what he regarded as justified goals.[36] Having been promised by Harper that biology would not have to struggle along with the inadequate conditions he had endured elsewhere, Whitman continued to work for better laboratory conditions, which he felt had failed to materialize. Having set his sights on a financially solid MBL, supported by Chicago, and on an inland biological laboratory and farm, he lobbied hard for support. Having been led to believe that he would continue to have a secure, high-quality group of faculty and students, Whitman also fought to retain his best people and to obtain better conditions and resources for those researchers. In all these arenas, he experienced frustrations and setbacks. Never a patient man and not one to accept compromises easily, he suffered as a result of his battles both at Chicago and at the MBL.[37]

Concerning buildings, Whitman was willing, though reluctant, to accept some crowding in the very first year with the full expectation of having that situation remedied in the second. Yet the second year found the then multiple departments moving from one set of crowded quarters into another crowded section of the Kent Chemical Laboratory.[38] Whitman wrote again and again to Harper that if the university could provide for chemistry, then why not for biology? In fact, Harper had promised $150,000 for biology buildings and the board of trustees had stated their intention to appropriate the designated funds. But intention proved stronger than action for a few years. In 1894 Harper acknowledged the need for adequate housing for biology, with its special requirement of "the most carefully adjusted accommodations," as the greatest need of the university.[39] Yet who would build this building?

Helen Culver did. This remarkable woman had inherited the considerable estate of Charles J. Hull and had contributed to Chicago's well-being in other ways before she determined to help the University. On 14 December 1895 she wrote to President Harper and declared her intention to make a gift "devoted to the increase and spread of knowledge within the field of the biological sciences."

> I mean to provide: (1) That the gift shall develop the work now represented in the several biological departments of the University of Chicago by the expansion of their present resources; (2) That it shall be applied in part to an inland experimental station and to a marine biological laboratory; (3) That a portion of the instruction supported by this gift shall take the form of University Extension Lectures on the West Side of Chicago. These lectures shall communicate in form as free from technicalities as possible the results of biological research.[40]

Actually, it seems that Harper had to talk her into giving the money to biology rather than to the arts as she had originally intended, but they did agree finally.[41]

Whitman was especially excited at the prospects for his inland laboratory and for the MBL as well as for Chicago. But the various interested parties eventually decided to spend all the money for biological buildings at Chicago instead. The West Side lectures seem to have evaporated as well. Rather than erecting one building, they decided to construct a quadrangle of four showcase buildings. The zoology, physiology, anatomy and botany departments each acquired its separate building, united by walkways and cloisters, which allowed some autonomy as well. At Helen Culver's request, the university

designated the unit as Hull Court, a cluster of well-designed buildings also equipped with modern apparatus through this benefactor's further donations. As Whitman recorded at the grand cornerstone laying,

> The Culver gift came to us all as a grand surprise. Our earliest days in the University were spent in the garrets and kitchens of a tenement house. We were then tenderly transferred to the unused corners of Kent Chemical Laboratory where . . . we struggled for three years for bare existence. . . . Just as our hopes had cooled to near the freezing point came . . . the story, told in all the brevity and gravity that befit great deeds: 'A gift of a million to Biology.'[42]

The buildings opened in 1897, and biology was placed on a solid ground for the first time at Chicago.[43]

With buildings eventually in place, Whitman still worried about the MBL and his plans for an inland experimental station. In 1902 he almost succeeded in putting together a plan to provide financial security for the MBL, but the plan involved giving some control—or at least apparent control—to a group of people from Chicago, an idea that the MBL trustees vehemently opposed.[44] In fact, some of those trustees complained that Whitman and Chicago were trying to take over the MBL. This charge hurt Whitman deeply because he had worked so hard, and at considerable personal cost, to maintain the MBL as a truly national facility not connected with or controlled by any one university or financial group. He believed that the offer from a group of Chicago supporters did not in any way threaten the MBL's continued independence and felt betrayed when others found his intentions suspect.[45] In turn, Whitman opposed an alternative plan for the Carnegie Institution to support the MBL, which would have entailed a shift away from the strong teaching tradition to a research focus, as well as some loss of control. After the difficult negotiations of 1902, Whitman in effect gave up the directorship of the MBL to his assistant Frank Lillie, even though he did not officially retire from the position until the laboratory's twenty-first birthday, in 1908.[46]

While the MBL grew increasingly successful despite its financial controversies and its lack of support from the University of Chicago, Whitman's long-anticipated inland biological station never materialized. Probably ever since his time at the Allis Lake Laboratory, Whitman had envisioned an inland experimental research station, which, he added later, could also provide animals and plants for the laboratory research in Chicago, a function that he later assigned to his prospective biological farm. Even in his earliest correspondence with Harper outlining the directions Chicago ought to follow in biology, Whitman stressed the marvelous opportunity offered by having a lake biological observatory, as he then envisioned it. As he pointed out, "Our location combines so many natural advantages in the way of lakes and rivers that we can easily lead the world in this work. A *Lake Biological Observatory*

such as I have suggested in our 'Programme,' in combination with *A Marine Observatory* will make us masters of the situation, and place the sciences of life, Physiology, Medicine, and all the rest on a footing that will simply surpass anything hitherto known in the world." We have the MBL already, he pointed out, so

> shall we fail to take the finishing step—that of planning a *Lake Observatory* for experimental research? I am sure your plans are too large to let this opportunity slip. This is something that to my mind will add much more to the enduring fame of this university than the establishment of an astronomical observatory . . . [because] the former stands for something that *other universities are not likely to duplicate*, and for something that the biological sciences the world over will pay homage to.[47]

Despite repeated pleas such as this, Whitman never persuaded Harper or anyone else to undertake the establishment of his inland laboratory. Helen Culver had intended to support the project, and presumably would have done so had not the economy caused the buildings for the Chicago campus to absorb so much of her gift. Only later, under Whitman's successor Frank Lillie and with Lillie's money, did Chicago begin to approach the facility that Whitman had envisioned, though by then in a different form more along the lines of a biological farm.[48]

In addition to his problems with buildings, money, and attempts to develop new facilities such as the inland laboratory, Whitman also had the usual troubles with and about faculty and students. Whitman seems to have inspired great loyalty from many of his faculty members, especially in the early years when he took a more active role in departmental administration and when the group remained relatively small and congenial. But he did not always have such success with Harper, and there were numerous skirmishes over the number of faculty positions, the number of fellowships for graduate students, and salary support for faculty. In 1894, for example, Lillie graduated and left for Michigan and then Vassar College, moves that Whitman very much regretted but could not prevent. Fortunately for Whitman, he did bring Lillie back to Chicago as an assistant professor in 1900.

Yet that success of 1900 followed on a particularly trying year, in which Whitman, probably not coincidently, had begun to withdraw quite considerably from departmental affairs. In 1899, Chicago lost both William Morton Wheeler and Shosaburo Watase. Harper had complained that Watase, in particular, was an "expensive luxury." His small class enrollments condemned him, in Harper's practical eyes. Yet to Whitman, Watase was "the broadest and soundest student of cellular biology in America," even surpassing Edmund Beecher Wilson. In addition, Watase was rare in his combination of physiological and morphological work, and of plant and animal studies. "All advanced students in cellular biology, whether in Botany, Zoology, or Anat-

omy, ought to go to Watase," Whitman insisted.[49] Because Watase gave "honor to the University," Whitman felt that Harper must keep him. Yet Harper remained sufficiently noncommittal that when Watase received a solid offer to return to Japan to teach, he went unhesitatingly. Harper similarly failed to understand why keeping Wheeler was a high priority, and Wheeler left for a distinguished career at the University of Texas and then at Harvard.

Also in 1899, Whitman needed to replace the paleontologist George Baur who had originally come with Whitman from Clark and who had recently died. Whitman had lost three positions by 1899, partly through what he probably regarded as Harper's lack of proper support. To add further insult, Harper proposed to give Whitman only two positions to make up for the three. Presumably Harper thought that Watase, with few students, did not have to be replaced. In addition, the continued arguments over whether paleontology properly belonged in biology or geology had left Baur with few students. Whitman was outraged. In a lengthy letter lambasting Harper's descent to "the level of the Mississippi Valley," he deplored the loss of men and the unfulfilled promises for equipment.[50] Chicago had once been the best, he wrote, but no longer. In the face of what he saw as a hopeless lack of support, he nonetheless still proposed to hire the very best scholars available, namely Frank Lillie and Thomas Montgomery. In fact, he did not succeed in appointing Montgomery, who was then comfortable at Pennsylvania, but hired Charles Davenport instead. The disaster was perhaps not so horrific as Whitman presented it, but replacing Wheeler and Watase with Lillie and Davenport did change the emphasis of the department somewhat, especially in moving away from cytological and behavioral studies.

In all these episodes of hiring and of lobbying for resources generally, Whitman played a strong directive role and held his convictions as inviolate. He hated to compromise when he felt he was right. Although he undoubtedly managed at times to irritate Harper and other administrators, it must have been clear that Whitman was doing an exceptional job. The department of zoology produced the largest number of Ph.D.'s, and succeeded in finding them jobs, often very good positions not limited to the zoological subset of biology. Zoology had an impressive research and publication rate, as revealed in the university's *Decennial Reports*. With Whitman's editorship of the *Journal of Morphology* and the *Biological Lectures*, as well as his role as founder of the *Biological Bulletin*, in addition to Whitman's and then Lillie's directorship of the MBL, Chicago visibly excelled throughout the United States.

At Chicago, Whitman dominated the zoology department with his autocratic style of leadership. Whitman was never "one of the boys."[51] He made the major decisions, and he suffered or rejoiced largely alone over the resulting failures or successes. Dedicated above all to superior research, Whitman never worried much about formal lectures or other typical aspects of university life.[52] He ignored many of the formalities and other trappings of academia as well. Most of his colleagues seem to have respected his approach and to

have admired his high ideals. Yet if conditions were then anything like today, we can be sure that his aloof and dictatorial approach did not please everyone, especially administrators. Perhaps Whitman failed to get as much as he wanted from Harper at times because he did not really work with Harper. Yet perhaps he did well at other times because he so clearly believed in what he was doing and so clearly obtained impressive results.

Whatever the attitudes toward Whitman's leadership in the early years, as Chicago became better established and as other departments began competing more successfully for funds, Whitman withdrew increasingly from administration and concentrated on his own research with pigeons. Moreover, he established his pigeon colonies at his home rather than on campus (for various reasons), and he increasingly absented himself from the university. As Lillie took over the actual running of the department not long after his arrival in 1900, he moved toward a more participatory form of control that worked well for the different groups with their evolving goals. Much of the work remained the same under Whitman and Lillie but with changes of emphasis and detail.

Whitman as Teacher

Mall cited Whitman's excellence as a teacher as yet another reason that Harper should make every effort to obtain Whitman for Chicago. Yet Whitman, like Mall himself, clearly excelled in some aspects of teaching and not in others.[53] Whitman disliked undergraduate teaching and generally avoided it. Even graduate instruction he accomplished more through visits to the students at their laboratory desks than in a formal classroom setting, thereby following the model of his own German mentors such as Leuckart.

The earliest evidence of Whitman's approach to teaching comes from his visit to the Imperial University of Tokyo. There, in a very short time, Whitman attracted great respect from his four students, each of whom continued his zoological research after Whitman left. As those students recalled later, Whitman emphasized the importance of careful, detailed work, with technical accuracy the basis for success. As one student recorded, "His way of supervising our work was very kind and earnest. Twice a day, once in forenoon and once in afternoon, he asked about the progress of the work and then gave us necessary criticism and suggestions. To look after the work of the students twice a day, is the way common in German universities. Weismann in Freiburg used to do the same."[54] In Tokyo, Whitman helped students to learn English and German; he introduced them to fundamental problems of the day and to current techniques; he taught them how to carry out research and shape the results into publishable form. Only occasionally did he lecture to his students, and then primarily as an introduction to recent books or important ideas. His training system worked well for his Tokyo group.

His approach also worked well in the early years of the MBL. There Whit-

man collected a group of promising young researchers and arranged for them to teach the courses, which he insisted should form a vital and essential part of the MBL program. From the very first year, when the MBL had a total of only seventeen people in attendance, Whitman relied on others to do the direct teaching.[55] He organized the laboratory and its set of courses, then taught by example and by looking over the shoulders of researchers involved in work he found interesting. Cornelia Clapp, one of the students of that first year at the MBL and a much admired researcher there for the rest of her life, reported that she especially loved the MBL that first year. It was quiet and she appreciated the low-profile support that Whitman gave the students.[56] In fact, Clapp admired Whitman and his work sufficiently that she decided to attend the University of Chicago for her Ph.D., the first such research degree readily available in biology to women.[57] It became part of the yearly routine for Whitman to pack up his necessary materials and his students and head for what British zoologist E. Ray Lankester had labeled the "spasmodic descent upon the seashore."[58] Thus, work at the MBL and at Chicago blended together during the early 1890s, and the combination helped to cement the feeling of community and cooperation in research that Whitman regarded as fundamental.[59]

At the MBL after the first year or two, Whitman began to build a research program that new students were expected to join. As Edmund Beecher Wilson, Edwin Grant Conklin, and Whitman began to recognize the potential significance of their overlapping researches into the details of early cell lineages of developing organisms, Whitman encouraged other students to participate with studies of different organisms.[60] Cell-lineage work, inaugurated by Whitman's work on leeches, involved the tedious, meticulous tracing of exactly what each cell does as it undergoes cell division after cell division: What is each cell's lineage? Individuals working on different organisms then compared their results and discussed alternative theoretical interpretations of the differences and similarities in developmental patterns and processes. This cell-lineage and related work on early development became the hallmark of MBL and Chicago research during the first decade.

When Frank Lillie decided in 1891 to go to Clark University to study with Whitman, Whitman urged him to begin that summer by attending the Woods Hole session. There Lillie learned that he was expected to join in and pursue cell-lineage work. The only real question concerned which organism he would choose. He decided to work on the freshwater clam, *Unio*, thinking that it would provide useful comparative information. Indeed it did. But Lillie had to lug his heavy buckets, boots, and other apparatus by train back and forth to the nearby town of Falmouth to obtain the freshwater species.[61] Notwithstanding the extra effort, Lillie clearly felt privileged to be a part of such an active and friendly working group of researchers as he encountered in Woods Hole. Whitman's approach to graduate supervision succeeded in attracting such enthusiastic, eager, hard-working, and loyal students.

At Clark University, despite its orientation toward graduate work, Whitman had had only a few graduate students during his two years on the faculty. As Hall noted at Clark, Whitman "had never taught and found the requirement of our minimum of two hours weekly somewhat irksome."[62] Presumably, in the laboratory he continued his over-the-shoulder approach to teaching.

Whitman acknowledged in his first Decennial report to Harper that the zoology department at Chicago, as at Clark, had always emphasized research with considerable success. Also as at Clark, Whitman paid little attention to undergraduate education at Chicago and cared little about enrollments and lecture offerings. By 1897, he rarely appeared in his office because he was working at home with his pigeons.[63] His approach to graduate students continued along his earlier lines, only perhaps with not quite such uniform success in the larger environment of Chicago. As one student, Horatio Hackett Newman, reported:

> Dr. Whitman's treatment of his graduate students was somewhat harsh. His plan was to let each student work out his own salvation. In brief, he used the "sink or swim" method. Sometimes his result was good, sometimes bad. The present writer's experience was similar to that of several others. When I was first appointed a Fellow, Dr. Whitman by correspondence immediately assigned me a research program: "The Origin of Metamerism," using the annelid *Podarke*, as material. I was told to go to Woods Hole, to study the development of this species and to preserve all stages for microscopic examination when I came to Chicago in the autumn. No reading was suggested and no directions were given as to how to go about the work. I did as I was told, collected stages of development all summer. When these were examined in Chicago it was found that no metamerism had occurred, but that larvae had retrogressed in later stages. Evidently some special food was required for later development. Here a little guidance would have obviated the failure. Of course, I was too young and ignorant in biology to have been put on my own, and this initial failure nearly made me give up trying to be a biologist. Fortunately for them, many other graduate students of Dr. Whitman came through the ordeal without damage to their self-confidence.[64]

Actually, so did Newman, or at least he recovered his self-confidence sufficiently to complete his degree at Chicago in 1905 and to join the faculty thereafter (in 1911).

In fact, the zoology department had by far the largest number of students and largest number of graduates of the biological departments at Chicago throughout Whitman's time there, as he enjoyed pointing out to Harper. The list of Ph.D. degrees awarded in zoology, under Whitman's leadership, demonstrates his success in attracting students both to Chicago and into his own areas of research (see Appendix). The particular set of subjects covered was unique to Chicago.[65] A few of the Ph.D. students may have worked with ad-

visors other than Whitman, yet Whitman exerted an important impact on most, introducing them to a research community and to his set of research problems and methods that then guided their own work. My cursory and unsystematic look at theses from Chicago and from Johns Hopkins, Harvard, Princeton, and Yale at the same time reveals a decidedly stronger emphasis at Chicago on early development, cytology, relations of embryology to evolution, behavior, and study of organisms as a whole, all of which characterized Whitman's work.

Whitman clearly worked hard to establish the sort of setting he found appropriate for a major research university. He worked for buildings, equipment, a marine laboratory and funds for students to do their research there, and to obtain and retain the best faculty. The Chicago department produced an impressive number of Ph.D.'s, a remarkable number of whom became professional biologists and continued their research after graduate school.[66] As an administrator and graduate teacher, Whitman was exceptionally successful. Yet none of this successfully addresses the question whether Whitman generated an identifiable Chicago style of work in biology, or at least in zoology. For an answer, we must look at Whitman's particular research and at the impact it had on colleagues and students at Chicago. Were there problems, techniques, assumptions, frameworks, or general approaches that characterize Whitman's work as well as the work of the Chicago zoological community? Did Whitman inaugurate a Chicago style of work?

Whitman as Researcher

In his earliest study of living organisms, as a boy, Whitman was attracted to birds. At age twelve, in 1854, he had a pet blue jay, and young Charles taught himself taxidermy in order to stuff and mount his pet when it died. He developed a strong fascination with natural history generally.[67] After failing the physical examination in the draft for the Civil War, presumably because of poor eyesight, Whitman entered an academic career, studying at Bowdoin College and teaching school to earn his way. It was only after attending Louis Agassiz's Anderson School of Natural History at Penikese Island in 1873 and 1874 that Whitman decided to study biology. During those summer sessions he kept largely to himself but explored and questioned.[68] On deciding to become a professional biologist, he went to Germany in 1875 to study natural history. He chose to work in Rudolf Leuckart's laboratory in Leipzig, where he learned the most advanced techniques for sectioning, staining, and preparing materials for microscopic study.[69]

For his Ph.D. dissertation, Whitman decided to study the embryology of several species of the leech *Clepsine* rather than the ascidians he had examined at Penikese.[70] He obviously spent considerable time in the library, reviewing earlier work on the leech as well as work on the developmental problems he found interesting. He probably concentrated on embryology, as so many others did at the time, because of the excitement about early development, stimulated in part by discussions of evolutionary questions and in part by technical advances that occurred between the 1850s and 1870s. In his dissertation, Whitman made it clear that he felt he had entered that vital world of morphological research and all stages of early development that Leuckart and others inhabited.[71] From the very formation of the egg cell to full development of the differentiated neurular stage, Whitman used the most advanced techniques and meticulously detailed his observations and their significance in light of other studies on the same and related species. Comparisons with vertebrates in particular revealed the degree of similarity and probable genealogical relationships of these leeches to other life forms.

Of special interest in Whitman's dissertation, given his later emphasis, is his discussion of cleavage. Recent histological work with improved techniques had demonstrated the developmental significance of cleavage for a number of researchers such as Alexander Kowalevsky, Edouard van Beneden, Wilhelm His, Carl Rabl, Leuckart, and others. Presumably, researchers in Leuckart's laboratory were predisposed to believe that, as Whitman wrote,

> in the fecundated egg slumbers potentially the future embryo. While we cannot say that the embryo is predelineated, we can say that it is predetermined. The "Histogenetic sundering" of embryonic elements begins with the cleavage, and every step in the process bears a definite and invariable relation to antecedent and subsequent steps. . . . It is, therefore, not surprising to find certain important histological differentiations and fundamental structural relations anticipated in the early phases of cleavage, and foreshadowed even before cleavage begins.

Such a position specifically denies that the embryo lies strictly preformed in the egg and must simply grow. Rather, the egg parts are more like building blocks that must be put into their proper places to have value for future differentiation. Such features as bilateral symmetry appear early, while other features follow later because "the egg is, in a certain sense, a quarry out of which, without waste, a complicated structure is to be built up; but more than this, in so far as it is the architect of its own destiny. The raw material is first split into two, four, or more huge masses, and some or all of these into secondary masses, and some or all of these into tertiary masses, &c., and out of these more or less unlike fragments the embryonal building-stones are cut, and transported to their places of destination."[72] That cleavage processes and patterns have a significant role in effecting differentiation Whitman did not doubt, but that fact played only a small part in his research of 1878.

In 1879–80, Whitman went to the Imperial University of Tokyo where he pursued his developmental study of leeches. Then a visit to the Naples Zoo-

logical Station during his return trip to the United States in 1882 and an assistantship in zoology at Harvard University's Museum of Comparative Zoology under Alexander Agassiz from 1882 to 1886 took him to other, related studies. Whitman published a series of articles on microscopical methods, leading eventually to a very useful book outlining research techniques as well as to several substantive papers from his work in Japan, Naples, and the United States.[73] Only in 1886 did he return directly to his studies of early developmental stages and to the significance of cleavage. At that time, he was director of the Allis Lake Laboratory near Milwaukee, Wisconsin, and had convinced Edward Phelps Allis to support an American biological journal.[74]

When that new *Journal of Morphology* appeared in 1887, Whitman included two of his own studies, which considered respectively the origin and fate of the germ layers in the leech *Clepsine*, and oökinesis (or cell development). Both papers stressed the importance of cytoplasm as well as the nucleus in development, insisting that any hypothesis that stressed the role of the nucleus to the exclusion of the cytoplasm simply could not explain the facts.[75] Both nuclear and cytoplasmic forces work together, Whitman insisted; we must therefore recognize that a variety of forces, influenced by heredity as well as by present conditions, direct all developmental stages and that we must move beyond the study of patterns to look also at processes if we are to understand development.[76] At the MBL, Clark University, and Chicago, Whitman interpreted this concern with both patterns and processes at the same time as a call for both morphological and physiological work. Individual researchers might concentrate on one side or the other, just as individuals would choose different organisms, but these specialists must then work cooperatively in order to carry out proper biological work."[77]

What Whitman offered in his work before arriving at Chicago was a very solid demonstration of the most advanced microscopical techniques and methods, a deep acquaintance with the English, German, and French literature concerning development, and an awareness that many important questions remained open with merely suggestive lines of attack or preliminary hypotheses.[78] Whitman was fully aware that researchers disagreed on many points and on interpretation. Careful technique, thorough familiarity with other work, cautious sorting out of possibilities, and working toward facts and solid interpretations should characterize biological work. With this set of approaches, he framed a style of biological work that was adopted by a growing community.

At the MBL, Edmund Beecher Wilson had begun to conduct his own studies of early development of the annelid *Nereis*. Like Whitman, Wilson became convinced that the earliest stages of egg formation and especially cleavage had significance for later differentiation.[79] Whitman and Wilson discussed their respective work, and Whitman encouraged Wilson to contribute his results to the new *Journal of Morphology*. As Wilson lectured to the embryology course each summer, he carried his conviction about early development to new biologists as well. In 1891, when Wilson learned that Edwin Grant Conklin, then at the U.S. Fish Commission, was also studying early development, namely of the gastropod *Crepidula*, Wilson went to talk with Conklin and invited him to the MBL to speak with Whitman. Whitman encouraged Conklin to contribute to the *Journal*, then invited him to join the MBL staff for the next summer. This move took Conklin away from the emphasis on later, germ layer stages of development, which his Ph.D. dissertation advisor William Keith Brooks emphasized, and toward Whitman's concerns. Thus, at the MBL Whitman began to develop a community of researchers with common goals, carrying out their individual studies on different organisms and then comparing results. Such comparisons would yield useful information for establishing genealogical or evolutionary relationships as well, Whitman, Wilson, and Conklin believed, and they all regarded improved understanding of evolution as vitally important. As the 1890s progressed, Whitman also began to focus his attention and that of his scientific community on major theoretical problems directly concerning development and heredity.

One such problem concerned the status of the cell theory. As Whitman recognized, "Each cell leads a double life; an independent one, pertaining to its own development alone; and another incidental, in so far as it has become an integral part of a plant."[80] This view had recently reemerged with force in researches claiming that parts of an organism, such as an isolated blastomere, could separate themselves from the organism and still develop independently. Yet development also requires organization. The cells do not operate completely independently, but must be integrated as part of a whole organism. The relations among the cells are as important as the cells themselves, so that "every elementary part possesses a power of its own, an independent life, by means of which it would be enabled to develop independently, if the relations which it bore to external parts were but similar to those in which it stands in the organism."[81]

As a result, organization is key. Evidence from half and quarter embryo experiments, which suggested that cell division divided predelineated areas of the egg, did nothing to undercut Whitman's absolute conviction that organization of the whole organism is necessary for normal development to occur. Whitman endorsed Thomas Henry Huxley's view that "they [the cells] are no more the producers of the vital phenomena than the shells scattered along the sea-beach are the instruments by which the gravitative force of the moon acts upon the ocean. Like these, the cells mark only where the vital tides have been, and how they have acted."[82] Given his emphasis on organization of the whole, on what Whitman called an organismal viewpoint, the way to understanding development necessarily lay with addressing processes, such as cleavage, of the developing whole. Patterns such as occur in the production of metamerism served as obvious paths of inquiry. Such concentration on the

organization of the whole, approached in a variety of ways, characterizes the work of many Chicago biologists.[83]

With the *Biological Lectures* presented to the MBL community and intended to address shared concerns, Whitman encouraged discussion of preformation and epigenesis, of the relative roles of the nucleus and cytoplasm, and of the validity of "organic physics" to parallel organic chemistry. Most of the lectures fit neatly together around the general themes of understanding the patterns and processes of development, particularly early development. Most of the Ph.D. students from Chicago worked on problems within that general framework as well, with many going on to advocate an organismal approach to biology thereafter. As Newman noted, Whitman usually suggested the students' beginning research topics and the approaches to them and continued to exert a powerful influence thereafter.

The influence also becomes apparent as some of the students' dissertation projects reflect Whitman's rather abrupt shift of emphasis after 1897. In 1897 the MBL suffered a severe financial and ideological crisis in which Whitman insisted unyieldingly that the laboratory must become a truly national rather than merely local organization and that it must have sufficient operating funds. Evidently, it was in 1897 also that Whitman returned to full-time research on birds, after beginning to develop a pigeon colony in 1895. After considering early development studies and the evolutionary relationships that these studies revealed, Whitman may have decided, as others did, that more productive results in developmental studies lay elsewhere. All the comparative studies had established much about development and the significance of cleavage but less about larger questions, especially those concerning evolution. Embryologists had begun to move toward other, more manipulative, experimental approaches, whereas Whitman chose to move in other directions.

Even while stressing development in his early work, Whitman had also examined those other aspects of the natural history tradition perpetuated by Agassiz: heredity, behavior, life history, and the anatomical details of organisms. The behavior of leeches, for example, had raised for Whitman the question of whether they acted instinctively or had some other form of intelligence. By 1897, he had begun to focus on that work and to turn especially to pigeons for further evidence about behavior and evolution. Pigeons made sense at Chicago as marine organisms did not, because he now wished to address problems requiring live rather than prepared organisms. At first, Whitman transported his pigeons between Chicago and Woods Hole by train, carrying the birds with his other baggage so he could properly care for them. When the railroad officials finally forbade this practice and required the birds to travel by separate express, many more died—too many. "Indeed," Lillie recalled, "the transfer became an intolerable burden, and he relinquished his charge of affairs at Woods Hole rather than curtail his own research."[84] As Burkhardt (in this volume) shows, studying behavior of living organisms, and especially of birds, entailed considerable cost.

Although Whitman actually published very little of his work on pigeons, he did amass tremendous amounts of research results, which his student Oscar Riddle shepherded into press after Whitman's death. Riddle was just one of the several students who turned with Whitman to pigeons and to problems of heredity and evolution. Yet Riddle was undoubtedly the closest and most loyal follower, who spent most of his career working with Whitman's pigeon colony at Cold Spring Harbor where they were, in effect, banished after Whitman's death.[85]

The Chicago zoology department never fully embraced Whitman's particular brand of evolutionary or behavioral study, or his pigeons, in the way that they had the work on development and heredity, even though the university had begun with a strong interest in neurobiology and psychobiology. Students such as Riddle and Wallace Craig, who moved into behavioral studies, did not fit into zoology or even into biology more generally, as Whitman himself did not after 1897 or so. Perhaps this division resulted because Whitman had so effectively established the study of development and heredity as appropriate that the zoology department had trouble accepting this shift to another set of problems. Perhaps, as Burkhardt suggests, the department had trouble accepting Whitman's failure to publish and his reclusive retreat to his backyard bird cages. The reasons for Whitman's shift, as well as the subsequent resistance by the department that he had himself built so painstakingly and with such investment of personal resources, deserve further investigation, which will carry the story into the twentieth century.

Conclusion: The Chicago Style

In my view, a biological style is characterized by a shared set of problems regarded as appropriate, techniques regarded as useful, and approaches regarded as productive. Those sharing a style participate in similar sorts of day-to-day activities because they have similar attitudes and approaches. Chicago did develop a style of work, I believe, a style based on commitment to the study of organization of whole organisms (and populations) and to cooperative and comparative study.

The list of researches and researchers in zoology, and associated fields, also reveals a continued strong commitment to problems of development and heredity, as do the lists of courses and seminar topics. Similar questions were asked, namely, what morphological patterns occur, and what physiological processes shape the development of the whole individual? Specifically, how do the organism and its parts act as a whole? Using a combination of traditional and up-to-date histological and microscopical techniques, as well as study of the organisms in their natural environments with summer trips to the MBL, these researchers pursued a wide range of separate but related questions. Their repeated sojourns to Woods Hole undoubtedly helped to create

the sense of shared mission that was lacking at other schools, for no other research institution sent so many students, younger investigators, and instructors to the MBL each year as Chicago did (or to any other research laboratory, it seems).[86]

Equally important in allowing Chicago to develop a persistent style of work was Whitman's neglect of undergraduate instruction, which permitted a highly specialized program of study. Other schools had to be more practical because, in addition to offering undergraduate study, they might also serve medical schools or agricultural interests. Chicago, as Pauly has shown, flirted with but never embraced medicine.[87] Also, those with older programs often were dominated by traditional natural historians, concerned with broad evolutionary questions and not specifically with early development. Some newer programs stressed experimental work, often on very specialized subjects, so that the leading researchers moved toward more radically manipulative experimental programs.[88] At Chicago, Whitman generally avoided hiring people with such concerns and simply did not listen if he was advised to pursue interests he did not find important. He wanted people who could work cooperatively together, who had shared convictions about problems, methods, and approaches but not necessarily any body of shared doctrine. By the time Lillie, who was much more open in approach and cooperative with administrators, took over, the pattern was successful and well established. Chicago's research style remained largely intact with such researchers as Lillie, Charles Manning Child, and Charles Benedict Davenport.[89]

What Lillie changed in the department at Chicago came primarily with his move to a more participatory approach to government and his concern with undergraduate as well as graduate teaching. He did not significantly change the style of research, although details and emphasis did shift, following similar lines of research with similar problems and similar approaches but in a new context of additional techniques and additional ideas. Lillie did add ecology to the department's offerings, but otherwise the departmental research and graduate training continued to concentrate on the study of development and heredity, with related work on evolution. Researchers such as Lewis Victor Heilbrunn, Albert William Bellamy, Benjamin Harrison Willier, William John Crozier, Warder Clyde Allee, Sewall Wright, Paul A. Weiss, Graham Phillips DuShane, Libby Hyman, Dorothy Price, Lincoln Domm, and Mary Juhn all fit in nicely at Chicago. The group at Chicago remained a cohesive community, at least for a while.[90]

In 1926, Lillie became sufficiently frustrated by the lack of adequate space for the growing group of researchers that he and his wife, Francis Crane Lillie, gave money to Chicago to construct the Whitman Laboratory. Designed as a research facility, separate from the teaching offices and classrooms, this laboratory attracted able researchers and undoubtedly helped to maintain Chicago's edge over other programs and its sense of "glamour."

Equipped with animal facilities, chicken yards, and other such advantages that Whitman and Lillie had long sought under the label of "inland laboratory" or "biological farm," the building became a workplace for the group studying various problems of sex inheritance and differentiation, as well as for some of the evolutionary and genetics work such as that done by Sewall Wright. Whitman would have approved of the laboratory and of the work that emerged from it.

A style of work thus characterized Chicago's contributions in zoology at a time when researchers there and elsewhere sought to define what biology should be like. The group shared problems and approaches and an attitude rather than a commitment to particular theories or conclusions. Elements of the style existed outside of Chicago as well, but I am aware of nowhere else where they came together in precisely the same coherent and cooperative way. Whitman surely deserves credit (or blame) for establishing this style at Chicago, which persisted beyond Whitman, into the twentieth century, although the extent remains to be explored more fully. Thus the style is not exclusively Whitman's but is, more properly, a Chicago style of biological work.

What this tells us about biology, and particularly biology in America, is that the particular combination of a strong-willed visionary individual with a formative resource-rich institution could produce a distinct tradition of biological work. Whether we label this characteristic work as a style or tradition does not matter. As long as we continue to examine what we mean by the label selected and to extend the exploration to research beyond Whitman, beyond Chicago, and even beyond America, the study of biological work and its context and its participants will help to illuminate the nature of biology.

Appendix: List of Chicago Ph.D. Degrees in Zoology. From Zoology Department Records, Chicago.

1894 Herbert Parlin Johnson, "A Contribution to the Morphology and Biology of the Stentors."
Frank Rattray Lillie, "The Embryology of the Unionidae."

1895 Albert Chauncey Eycleshymer, "Early Development of Amblystoma with Observations on Some Other Vertebrates."
William Albert Locy, "Contribution to the Structure and Development of the Vertebrate Head."

1896 Howard Stedman Brode, "A Contribution to the Morphology of Dero vaga."
Cornelia Clapp, "The Lateral Line System of Batrachus Tau."
Agnes Mary Claypole (Mrs. Robert O. Moody), "The Embryology and Oögenesis of Anurida maritima Guen."
Albert Davis Mead, "The Early Development of Marine Annelids."

1897 Charles Lawrence Bristol, "The Metamerism of Nephalis."
Samuel J. Holmes, "The Early Development of Planorbis trivolvis."
John P. Munson, "The Ovarian Egg of Limulus: A Contribution to the Problem of the Centrosome and Yolk-Nucleus."
1899 Emily Ray Gregory, "Observations on the Development of the Excretory System in Turtles."
Aaron Louis Treadwell, "The Cytogeny of Podarke."
1900 Michael Frederick Guyer, "The Spermatogenesis of Normal and Hybrid Pigeons."
1901 Elliott Rowland Downing, "The Spermatogenesis in Hydra."
Wilhelmina Entemann (Mrs. W. E. Key), "Coloration of Polistes (the common Paper Wasp)."
Ralph Stayner Lillie, "Excretory Organs of Arenicola cristata."
Virgil Everett McCaskill, "The Metamerism of Hirudo Medicinalis."
John McClelland Prather, "The Skeleton of Salaux Microdon."
1902 Eugene Howard Harper, "History of the Fertilization and Early Development of the Pigeon's Egg."
1903 Bennet Mills Allen, "The Development of the Ovary and the Testis in the Mammals."
William J. Moenkhaus, "The Development of the Hybrids between Fundulus heteroclitus and Menidia notata with Especial Reference to the Behavior of the Maternal and Paternal Chromatin."
1904 Charles Dwight Marsh, "The Plankton of Lake Winnebago and Green Lake."
John William Scott, "Studies in the Experimental Embryology of Some Marine Annelids."
Charles Zeleny, "Studies in Regulation and Regeneration."
1905 Lynds Jones, "The Development of the First Down and Its Relation to the Definitive Feather."
Horatio Hackett Newman, "The Morphogeny of the Chelonian Carapace."
1906 James Francis Abbott, "The Morphology of Coeloplana."
1907 Frank Eugene Lutz, "The Variations and Correlations of the Taxonomic Characters of Gryllus."
Oscar Riddle, "The Genesis of Fault-Bars in Feathers and the Cause of Alterations of Light and Dark Fundamental Bars."
Victor Ernest Shelford, "The Life-Histories and Larval Habits of the Tiger Beetles."
Charles Henry Turner, "The Homing of Ants: An Experimental Study of Ant Behavior."
1908 Charles Christopher Adams, "The Geographic Variations and Relations of Io."
Mary Blount, "The Early Development of the Pigeon's Egg from Fertilization to the Organization of the Periblast."

Wallace Craig, "Expression of Emotions in the Pigeon."
John Thomas Patterson, "Gastrulation in the Pigeon's Egg."
Katashi Takahashi, "Histogenesis of the Lateral Line System in Necturus."
George Washington Tanmreuther, "History of the Germ Cells and Early Embryology of Certain Aphids."
1909 Marian Lydia Shorey, "The Effect of the Destruction of Peripheral Areas on the Differentiation of the Neuroblasts."
H. L. Wieman, "A Study in the Germ Cells of Leptinotarsa signaticollis."
1910 George William Bartelmez, "The Bilaterality of the Pigeon's Egg: A Study in Egg Organization."

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Notes

1. J. M. Richards, *Modern Architecture* (Baltimore: Penguin Books, 1940, revised 1962), p. 71.

2. John F. Dryfhout, *The Work of Augustus Saint-Gaudens* (Hanover, N.H.: University Press of New England, 1982), p. 30.

3. Elihu Gerson, "Styles of Scientific Work and the Population Realignment in Biology, 1880–1930," presented at the Conference on History and Philosophy of Biology, Granville, Ohio, 1983; idem, "Scientific Work and Social Worlds," *Knowledge: Creation, Diffusion, Utilization*, 1983, *4*: 357–377.

4. Richard J. Storr, *Harper's University. The Beginnings* (Chicago: University of Chicago Press, 1966), pp. 3–6.

5. Storr, *Harper's University*, p. 6.

6. W. Carson Ryan, *Studies in Early Graduate Education. The Johns Hopkins University, Clark University, the University of Chicago* (New York: Carnegie Foundation, 1939), pp. 105–106, 108; Storr, *Harper's University*, p. 47.

7. Stanford was begun officially in 1887 but only really began recruiting faculty in 1891. As David Starr Jordan wrote to Harper, "I find that we are likely to cross each other's path more than once in the selection of our faculty," (28 July 1891); Storr, *Harper's University*, p. 69. Ronald Rainger points out, through personal correspondence and based on his work with the Columbia Archives, that Henry Fairfield Osborn also recognized the competition for good faculty at the same time.

8. Lincoln C. Blake, "The Concept and Development of Science at the University of Chicago, 1890–1905" (Ph.D. dissertation, University of Chicago, 1966), chap. 3, discusses a number of documents available in the University of Chicago Archives.

9. Harper to Herrick, 15 June 1892, Whitman Collection, Department of Special Collections, The Joseph Regenstein Library, University of Chicago (hereafter Whitman Collection, Chicago). For a discussion of Herrick's hiring and subsequent problems at Chicago, see also the biography by his brother: Charles Judson Herrick, "Clarence Luther Herrick, Pioneer Naturalist, Teacher, and Psychobiologist," *Transactions of the American Philosophical Society*, n.s., 1955, *47:* 1–85.

10. Herrick to Harper, especially 9 May 1892, Whitman Collection, Chicago; also letters in William Rainey Harper Papers, Chicago (hereafter Harper Papers).

11. Blake, "The Concept," p. 77.

12. Whitman to Harper, 19 December 1891, Whitman Collection, Chicago.

13. Storr, *Harper's University*, pp. 78–79.

14. Jordan to Whitman, May or June 1891 [Whitman rarely dated his letters], David Starr Jordan Papers, Stanford University Archives, Stanford, Calif. I thank Keith Benson for bringing this document to my attention. Orrin Leslie Elliot, *Stanford University. The First Twenty-five Years* (Stanford, Calif.: Stanford University Press, 1937), p. 62, confirms that Whitman was officially offered but declined a position.

15. Ryan, *Studies*, pp. 56–57, 59.

16. Ibid., pp. 62–63. Ryan cites a contemporary photograph of Frank Lillie's as evidence of the number who went with Whitman to Chicago.

17. Mall to Harper, 27 January 1892, Harper Papers, Chicago. Ironically, after all Mall's efforts to help Harper attract Whitman, Mall remained at Chicago only one year himself before moving to the Johns Hopkins Medical School as chairman of Anatomy when it opened in 1893. Mall corresponded with Harper's brother Robert, a friend of Mall's in Leipzig, rather than directly with William Rainey, as discussed by Dorothy Ross, *G. Stanley Hall: The Psychologist as Prophet* (Chicago: University of Chicago Press, 1972), p. 226, and decided early during his Clark stay that he wanted to leave and that Chicago was attractive.

18. Whitman to Harper, 21 March 1892, Harper Papers, Chicago.

19. Mall to Harper and Whitman to Harper, January through May 1892, Harper Papers, Chicago.

20. Ross, *G. Stanley Hall*, p. 226; letters, Harper Papers, Chicago; G. Stanley Hall, *Life and Confessions of a Psychologist* (New York: D. Appleton, 1924), pp. 294–297, reveal Hall's disgust and disappointment with Harper's move, which he compared to the action "of a housekeeper who would steal in at the back door to engage servants at a higher price," p. 296.

21. Ross, *G. Stanley Hall*, p. 227.

22. Ryan, *Studies*, p. 62.

23. Storr, *Harper's University*, p. 83; Blake, "The Concept," chap. 3. The charge against Harper was that he had opportunistically seized on the Clark group and had not kept promises to Herrick.

24. Herrick to Harper, 14 November 1898, Whitman Collection, Chicago. Herrick went to New Mexico and in 1898 wanted Chicago to set up a biological station for him on Lake Chapala in central Mexico, essentially to compensate for Harper's past injustices. He claimed that the station would follow along the lines of the Naples Zoological Station and requested a salary for himself and a small stipend for an assistant. Harper replied briefly and negatively.

25. Whitman, "Biological Instruction in the Universities," *American Naturalist*, 1887, *21:* 507–519.

26. Edward S. Morse, "Charles Otis Whitman," *National Academy of Sciences Biographical Memoirs*, 1912, *7:* 269–288; Frank R. Lillie, "Charles Otis Whitman," *Journal of Morphology*, 1911, *22:* xv–lxxvii; Jane Maienschein, introduction to *Defining Biology. Lectures from the 1890s* (Cambridge, Mass.: Harvard University Press, 1986).

27. Whitman, "Biological Instruction," p. 507.

28. Ibid., pp. 516–517.

29. Whitman, "Specialization and Organization," *Biological Lectures delivered at the Marine Biological Laboratory of Wood's Holl*, 1891, *1890:* 1–26; "The Naturalist's Occupation," *Biol. Lect.*, 1891, *1890:* 27–52.

30. Philip Pauly, "The Appearance of Academic Biology in Late Nineteenth-Century America," *Journal of the History of Biology*, 1984, *17:* 369–397, on pp. 382–387; Donna Jeane Haraway, "The Marine Biological Laboratory of Woods Hole: An Ideology of Biological Expansion," unpublished manuscript.

31. Whitman to Harper, 19 December 1891, Harper Papers, Chicago.

32. Whitman to Harper, n.d., probably early 1892, Harper Papers, Chicago.

33. Mall to Harper, 27 January 1892, Harper Papers, Chicago.

34. Blake, "The Concept," p. 135.

35. Gerald Geison has begun to examine the Chicago program in physiology, for example; see "International Relations and Domestic Elites in American Physiology, 1900–1940," in Gerald L. Geison, ed., *Physiology in the American Context, 1850–1940* (Bethesda, Md.: American Physiological Society, 1987), pp. 115–154.

36. Morse, "Whitman," p. 269.

37. Helen Frost to Lillie about Whitman's deep disappointment with the MBL's lack of support, 4 October 1911, Lillie Papers, Chicago; Whitman to Conklin and Wilson, letters throughout the 1890s, Whitman Collection, MBL Archives, Woods Hole, Mass.

38. Blake, "The Concept," p. 135.

39. Thomas Wakefield Goodspeed, "Helen Culver," *The University of Chicago Biographical Sketches*, vol. 2 (Chicago: University of Chicago Press, 1925), pp. 77–99, on p. 94.

40. Goodspeed, *The University*, p. 95; Helen Culver to Harper, 14 December 1895, Whitman Collection, Chicago.

41. Howard S. Miller, *Dollars for Research* (Seattle: University of Washington Press, 1970).

42. Goodspeed, *The University*, p. 96.

43. The new complex generated some of the usual controversy surrounding biological work at the time. Even Helen Culver received at least one letter criticizing her gift to the university. As antivivisectionist Mary Totten wrote, "We know, from the testimony of the operators themselves, that the greatest and most inexcusable cruelties that now have place on this earth take place in such laboratories under the name of 'scientific research'—and that, in such an institution as is proposed to be established

by your gift, these cruelties will be on a scale more appalling than ever." Such traditional attempts to sidetrack biology had little practical effect on Helen Culver or on the university.

44. Frank R. Lillie, *The Woods Hole Marine Biological Laboratory* (Chicago: University of Chicago Press, 1944), esp. p. 60; Jane Maienschein, "Early Struggles at the Marine Biological Laboratory over Mission and Money," *Biological Bulletin*, 1985, *168 suppl:* 192–196.

45. Whitman to Conklin, 2 March 1902, Whitman Collection, MBL Archives.

46. The MBL Archives and *Trustees Minutes* makes clear that Whitman had de facto retired after 1902. See "The Resignation of Prof. Whitman as Director of the Marine Biological Laboratory at Woods Hole, Mass.," *Anatomical Record*, 1908, *2:* 380–382.

47. Whitman to Harper, n.d., probably late 1891 or early 1892, Harper Papers, Chicago.

48. Whitman, et al., to the President and Board of Trustees, 3 December 1906, Presidential (Judson) Papers, Chicago; Adele E. Clarke, "A Biological Case Study: The Reproductive Research Enterprise at the University of Chicago," unpublished manuscript, 1984; idem, "Research Materials and Reproductive Physiology in the United States, 1910–1940," in Geison, *Physiology in the American Context*, pp. 323–350. Both articles discuss the Chicago efforts to establish a biological farm.

49. Whitman to Harper, 3 May 1899, Harper Papers, Chicago. Also, as Philip Pauly has pointed out, in personal correspondence, one should never underestimate the importance of prejudice against Watase as a non-aristocratic Japanese scientist.

50. Whitman to Harper, 12 September 1899, Harper Papers, Chicago.

51. As evident from letters between Lillie and others after Whitman's death, as Lillie was constructing a biography.

52. Blake, "The Concept," pp. 124–125; H. H. Newman, "History of the Department of Zoology in the University of Chicago," *BIOS*, 1948, *19:* 215–239.

53. Donald Fleming, *William H. Welch* (Boston: Little, Brown and Company, 1954), discusses Mall's teaching.

54. Chiyomatsu Ishikawa, "Professor Charles Otis Whitman," translated by Shigro Yamanouchi from *Magazine of Zoology*, 1911, *23:* 14, Whitman Papers, Chicago.

55. The MBL *Annual Reports* list the teachers for each session, as well as investigators and students.

56. Cornelia Clapp, "Some Recollections of the First Summer at Woods Hole, 1888," *Collecting Net*, 1927, *2 (4):* 3, 10.

57. Ann H. Morgan, et al., "Cornelia Maria Clapp," *Mount Holyoke Alumnae Quarterly*, 1935, *19:* 1–9.

58. E. Ray Lankester, "An American Sea-side Laboratory," *Nature*, 1880, *25:* 497–499.

59. Whitman often wrote about the need for specialization and cooperation working together in the same community. See, for example, "Specialization and Organization."

60. On the various cell-lineage studies, see Jane Maienschein, "Cell Lineage, Ancestral Reminiscence, and the Biogenetic Law," *J. Hist. Biol.*, 1978, *11:* 129–158. Wilson, Conklin, Lillie, and others often mentioned the way in which Whitman encouraged them to work together, comparing the results of their cell-lineage studies.

61. Lillie, "Autobiography," 1926, unpublished manuscript, Lillie Collection, MBL Archives.

62. Hall, *Life and Confessions*, p. 289.

63. Ishikawa, "Whitman," wrote that he was told when he visited Chicago that Whitman rarely ever came to the University to work but that he stayed with his pigeons at home; Blake, "The Concept," p. 124, commented that Whitman "justified his withdrawal from classroom contact with his students by insisting that American institutions were too patronizing and paternalistic." Also see Newman, "A History," pp. 221–222.

64. Newman, "A History," p. 221.

65. The full argument for this claim demands a much larger study, of course, but I feel confident of its accuracy. See list of Ph.D. degrees awarded, Zoology Department Records, Chicago, in the Appendix.

66. The list of Chicago Ph.D.'s in zoology shows that thirty-three remained professionally in zoology, including most of the men; Zoology Department Papers, Chicago.

67. Morse, "Whitman," p. 271.

68. Clapp to Lillie, 19 April 1911, Lillie Papers, Chicago; Lillie, "Whitman," p. xviii; Morse, "Whitman," p. 274.

69. Morse, "Whitman," p. 274; On Leuckart, see Klaus Wunderlich, *Rudolf Leuckart* (Jena: Gustav Fischer Verlag, 1978); a list of his students appears on pp. 41–51.

70. Charles Otis Whitman, "The Embryology of Clepsine," *Quarterly Journal of Microscopical Science*, 1878, *18:* 215–315; Morse, "Whitman," p. 274.

71. Lynn Nyhardt, "The Career of Experimental Embryology in Germany, 1890–1925" (Ph.D. dissertation, University of Pennsylvania, 1986), discusses the German morphological tradition, as does E. S. Russell, *Form and Function* (London: John Murray, 1916), and *The Interpretation of Development and Heredity*, 1930 (Freeport, N.Y.: Books for Libraries Press, 1972).

72. Whitman, "The Embryology," pp. 263–264.

73. Charles Otis Whitman, *Methods of Research in Microscopical Anatomy and Embryology* (Boston: S. E. Cassino, 1885); Lillie, "Whitman," pp. lxxiv–lxxvii, contains the list of other works.

74. For discussion of that laboratory, see Ernst J. Dornfeld, "The Allis Lake Laboratory," *Marquette Medical Review*, 1956, *21:* 115–144.

75. Charles Otis Whitman, "Ökinesis," *J. Morph.*, 1887, *1:* 228–252.

76. Whitman often argued for the importance of studying heredity and development, physiology and morphology. Especially see MBL *Annual Reports*. Also discussed in Jane Maienschein, "Physiology, Biology, and the Advent of Physiological Morphology," in Geison, *Physiology in the American Context*, pp. 177–193.

77. For discussion of Whitman's emphasis on cooperation, see, for example, Whitman, "Specialization and Organization;" and Maienschein, *Defining Biology*, esp. pp. 17–21.

78. Keith Benson, "Naples Stazione Zoologica and Its Impact on the Emergence of American Marine Biology: Entwicklungsmechanik and Cell Lineage Studies," *J. Hist. Biol.* (forthcoming), discusses the importance of technical developments and Whitman's role in introducing the latest techniques from Europe to the United States.

79. Alice Levine Baxter, "Edmund Beecher Wilson and the Problem of Development" (Ph.D. dissertation, Yale University, 1974), and later articles.

80. Charles Otis Whitman, "The Inadequacy of the Cell Theory of Development," *Biol. Lect.*, 1894, *1893:* 105–124, on p. 105.

81. Whitman, "Inadequacy," p. 106 (emphasis in the original).

82. Ibid., p. 124, quoting Huxley.

83. See, for example, Frank R. Lillie, *Problems of Fertilization* (Chicago: University of Chicago Press, 1919); Charles Manning Child, *Patterns and Problems of Development* (Chicago: University of Chicago Press, 1941); Jacques Loeb, *The Organism as a Whole* (New York: G. P. Putnam's Sons, 1916).

84. Lillie, "Whitman," p. lxiii; Ishikawa, "Whitman," p. 18.

85. George W. Corner, "Oscar Riddle," *Natl. Acad. Sci. Biog. Mems.*, 1974, *45:* 427–465; Jane Maienschein, "Riddle, Oscar" *Dictionary of Scientific Biography*, supp. 2 (N.Y.: Charles Scribners Sons, forthcoming); Oscar Riddle, ed., *Posthumous Works of Charles Otis Whitman*, vol. 1, "Orthogenetic Evolution in Pigeons"; vol. 2, "Inheritance, Fertility, and the Dominance of Sex and Color in Hybrids of Wild Species of Pigeons"; and Harvey A. Carr, vol. 3, "The Behavior of Pigeons" (Washington, D.C.: Carnegie Institution of Washington, 1919).

86. The MBL *Annual Reports* record where the MBL participants came from.

87. Pauly "The Appearance," pp. 382–387.

88. The series of histories of biology departments in *BIOS* details many of the early programs and how they changed.

89. Victor Chandler Twitty, *Of Scientists and Salamanders* (San Francisco: W. H. Freeman and Company, 1966). The flavor of the department, as well as the sense of importance of the work there, trickled out to prospective graduate students. As Victor Twitty recorded, when he began to apply to graduate schools some appealed "because of the glamour of their very names." Chicago and Harvard fit into that category. Twitty had just finished reading a book by the "celebrated (and controversial)" Child and found it exciting. Chicago offered Twitty a tuition scholarship "but left unresolved the matters of food and shelter," while his Harvard application was "returned without comment" because he had forgotten to sign it. When he received a better offer from Yale, he decided to go there rather than to Chicago. In retrospect, he realized that this was a fortunate choice, but at the time Chicago clearly offered more glamorous and exciting prospects than Yale. Various letters in the Harrison Collection, Yale University Manuscripts and Archives, as well as in the Lillie Collection, Chicago, 1919, show that Yale's chair of zoology, Ross Granville Harrison, sent one daughter to Chicago for undergraduate work and considered sending another to graduate school, partly because of the intellectual atmosphere there.

90. Newman, "History," pp. 226–228. Gregg Mitman, personal correspondence, points out that this cohesiveness should not be surprising, because Chicago experienced considerable "inbreeding." A high percentage of those hired by Chicago were Chicago products, and some department members were actually related. Mitman also suggests that as time went on and as some sorts of study (embryology, genetics, sex research) received greater support than others (ecology), some researchers began to feel alienated from the dominant Chicago style of work.

Part Three

Working at the Boundaries of Biology