Perspectives

ACCEPTANCE OF THE THEORY OF EVOLUTION IN AMERICA: LOUIS AGASSIZ VS. ASA GRAY

One of the strangest stories in this history of American science is that involving the lives, thoughts, and publications of two men—Louis Agassiz and Asa Gray. These two men, who were so very different both in education and personality, fought the battle for and against the ideas in Darwin's publication, *The Origin of Species,* during their whole lifetimes. Gray appeared the champion of Darwin's evolution and natural selection; Agassiz, with all the same knowledge at his fingertips, appeared not to comprehend these laws and vigorously fought to defeat them.

Asa Gray, a native New Yorker, was more or less a self-made man. As a youngster Gray enjoyed and appreciated nature. By the time he went to school and was working closely with Dr. James Hadley at the College of Physicians and Surgeons, botany had become his great love. Gray eventually received his Doctor of Medicine diploma at the college and became a doctor in the small community of Bridgewater, N.Y.

In his spare time Gray traveled around New York comparing, classifying, and trading plant specimens with Hadley and other scientists to whom Hadley introduced him. As his interest in collecting and naming plants increased and his pursuit of patients decreased, Gray's medical practice fell by the side. After his publication of several botanical textbooks, everyone was sending him plants to identify from all the new lands opening to the west. As his fame spread, various teaching positions were offered him. These were at his own school in Fairfield, at the Utica Gymnasium, and finally at Harvard University.

A slightly built man, quietly reserved and rather dignified, Gray had a terrible time lecturing to his students. However, the laboratory, herbarium, and botanical garden at Cambridge were another matter. Although he loved his systematic work, he soon became a virtual prisoner to it. The deluge of new specimens took all his time and he had to leave the collecting and field work, so important to all scientific men, to those of more robust nature.

Even though Gray's field work suffered, he never forgot the philosophical side of his science. He continually sought broad generalizations to cover his multitudinous data and specimens. His overall view of botany had been obtained initially from the *Edinburgh Encyclopedia;* and, later at Bridgewater, he had read Sir William Lawrence's *Lectures on Physiology, Zoology, and the Natural History of Man,* delivered at the Royal College of Surgeons. Three basic positions in this latter book impressed Gray. The first was the materialistic and empirical outlook of the book, the second was the idea that man was a part of nature, governed by the same laws as other organisms, and third was the idea of unity of the human race. Another idea which impressed Gray was Lawrence's reference to geographical isolation as a mechanism leading to new varieties, and the great changes which men and nature introduced into animals by selection. Later Gray encountered these ideas in Darwin's broad generalizations. Another source of Gray's philosophical ideas came from the colleagues and correspondents he consulted in his systematic work, particularly his colleagues in England whom he met there in 1840 when on a trip for the University of Michigan. From De Candolle, Gray got his view of species—a similar definition to that currently held and based on successful breeding. From his own work within species, Gray found varieties that were merely a slight variation to the species type itself. From these outside sources and his own hard work, he gained a high regard for an empirical approach. In addition, his intimate acquaintance with specimens collected from all over the world made him capable of forming his own broad ideas about the true geographical distribution of various plant groups. Geology, one of his hobbies, helped him as he incorporated his readings of Lyell's geological ideas into his botanical theories. During the 1840s, Gray still held to the idea of a creation of life; however, with his vast experience and large number of correspondents, he was aware of new ideas emerging worldwide. Although Gray was one who saw the scientific facts and believed his eyes before worrying about any religious dogma, he felt that man was one species from one unique origin. This fit nicely with his religious views.

Louis Agassiz met Gray during this period. Agassiz was already a giant in his own right in Europe, which he had just left to make his fortune in America in order to pay back old debts and finance new scientific ventures. Agassiz was the son of a Swiss pastor, deeply entrenched in religion from birth, although not giving allegiance to any particular church. From childhood he had loved science, even as Gray, but with more assistance from his family. Beginning in small Swiss schools, he studied diligently and eventually reached the great universities of that day in Germany, Heidelberg, and Munich. (Agassiz earned both the Doctor of Medicine and Doctor of Philosophy degrees in these schools.) These schools were based on a religious type of philosophy and to understand this, and particularly their *Natur-philosophie,* is to understand Agassiz.

Kant, Fichte, Shelling, and Hegel had been taught rapidly one after another in Agassiz' studies. All these

philosophies were based on the old question of the reality of the external world, the belief in an a priori knowledge independent of experience, and stemmed from Plato's ideas about the makeup of the world. Schelling thought natural facts were merely manifestations of the mind, although Schelling was more interested in the mind of man, while Agassiz got involved with the mind of God. Schelling believed that everything organic was a symbol. Agassiz changed this idea into a maxim that a species was a thought of the Creator. The scale of nature, ladder of perfection, or chain of being was a rigid and a priori scheme of things that precluded Agassiz' acceptance of modern evolution.

Agassiz held four main ideas, the first being a rational plan of the universe. The second was typological thinking. Special creation was the only source of life, and everything was the demonstration of creation and its Creator. All classification was nothing but categories of thought of the naturalist. Any natural class of organisims could be characterized by its type organism. For a system of these types, Agassiz moved to his ideal, Cuvier, the great comparative anatomist, under whom he studied in Paris after his work in Munich.

Agassiz' third idea centered around Cuvier's theory of catastrophism. Cuvier believed that life had been stopped throughout the world's history by a series of catastrophes. Since Cuvier (and also Agassiz from his work on fossils) knew that different successions of animals and plants had lived upon the earth and some explanation of the disappearance of some and the appearance of new types was necessary, he added that there were special creations after each catastrophe to repopulate the earth. Agassiz further added to this that wherever the animals are found now, that is where they were created and, if more than one creation for the same species was seemingly necessary, it was either that they were really two different species or that God had decided to create them in separate places. From Agassiz' work on glaciers it seemed to him that the last catastrophe had been a glacial one.

In accepting these views of Cuvier, Agassiz was presented with a problem. Because he also did not believe in variation in species (but only stages in their growth and development on their way to type), he had to create extra species from what Gray would have considered only varieties of the same species. This led to Agassiz' fourth idea which was that of an ontogenetic concept of evolution. Evolution in the form which Darwin proposed a few years later was completely foreign because of this idea. The only connection between species to Agassiz was idealistic; material connections were out of the question. Even man, Agassiz felt, had been created in special species (not races) which were not of the same lineage. (This idea created quite a furor when expounded by him in the United States around the time of the Civil War.)

These four main ideas of Agassiz were compiled with other data and good scientific observations and experiments into his *Contributions to the Natural History of the United States,* whose first volume came out only two years before Darwin's *Origin* and has since been recently republished in 1962 as *An Essay on Classification.*

Agassiz had a dynamic personality and a good speaking ability. He charmed everyone, from kings to colleagues, and used his charm to raise funds for his various projects, which were always in excess of his supply of funds. After his arrival in the United States in 1846, he soon became the center of focus for science, leaving his quiet, retiring, and poor public-speaking friend, Gray, completely in the background. Students and people of all classes thronged to hear him at the Lowell Institute Lectures where he first spoke on *Plan of the creation, especially in the animal kingdom.* Public lectures on scientific matter were considered both entertainment and adult instruction and were very popular. Gray had appeared also as a guest lecturer, but with his poor delivery he was completely overshadowed by this foreigner whose very accent only seemed to charm the audience more.

Soon Agassiz had even squeezed himself into the same university as Gray, Harvard, and was raking in money from university heads to private donors. These monies were being used for zoological collections and the building of a museum to house them, Agassiz' dream. Meanwhile Gray still had to finance the herbarium and gardens, plus collecting expeditions, from his own pocket and that of his few generous friends who contributed.

In the 1850s, Agassiz, busy with his museum and all the new animals and plants, both living and fossilized, and the geological formations of his new country, became more specialized. His correspondence with Europe dropped to a minimum and soon he seemed to be entirely devoted to American science. Gray, on the other hand, was branching out. His correspondence became greatly strengthened by his second and third trips abroad in 1847 and 1855. Plants from different countries were constantly arriving in Cambridge for Gray. Also, several of his English friends had published on various matters akin to some of the ideas to which Darwin would later refer, naming the Galopagos Islands and their geological formations and biogeography. This data fitted in nicely with the theories of geographical distribution studies and geological records which Gray was working on. Because of the ideas which Gray expressed regarding his friends' publications and the ideas in his own publications, in his correspondence with Joseph Hooker, Sir Charles Lyell, and later Darwin himself, Gray was let in on one of the biggest secrets of science at that time, the preparation of Darwin's *Origin.*

His dislike and opposition to the views of his colleague, Agassiz, also helped in his selection. Agassiz' views, which Darwin called delightful but not clever for a man with such immense knowledge, made Gray accepted as Darwin's mouthpiece in America; and, since he knew so far in advance (almost three years), he had time to prepare the scene. The intimacy of this small group held *the secret,* although some such as Huxley suspected it from talking to Darwin.

In 1859 the world was shattered by Darwin's publi-

cation. To Agassiz it was a complete blow. Previous to his *Contributions,* especially the first volume, others had tried to form a theory of evolution (or transmutation as Agassiz insisted on calling it). These works were based on a priori ideas and could easily be argued down by Agassiz. Darwin's staggering tome of scientific observation upon scientific observation touched every point upon which Agassiz had touched in his *Essay,* but did it empirically instead of idealistically. Agassiz was hard put to criticize it, and apparently did not understand it, since it was written in complete contradiction to his rigorous upbringing in *Natur-philosophie.* Also, being involved in so many activities in America, he had no time to thoroughly acquaint himself with the ideas expressed.

By 1859 Agassiz considered himself to be the world's leading authority in all scientific matters, for wasn't he the scientist of *two* worlds, old and new, hadn't he produced volumes on both living and fossil animals, and hadn't he the fine education of Europe which he was attempting to share with these poorly educated and plodding Americans, via new museums, public lectures, and highly intellectual classes at their best university? The idea of people using his data for generalizations other than his own was very distressing.

Even Agassiz' students were in a furor as they joined the throng who eagerly awaited the special meetings set aside by the American Academy of Arts and Sciences and the Boston Natural History Society so that Gray and Agassiz, in particular, could discuss this important *little green book* (in reference to binding of Darwin's first edition put out by John Murray, London).

Gray would say (written in publications of the meetings later and elsewhere) the things he knew to uphold Darwin's theory from his own work and that of others, including Darwin, and then would launch an attack on the opposing point of view. Agassiz remained undaunted; and, while admitting that geological records, embryological records, and the general succession of animals at the present time all agreed, he stuck firmly to a defense of the same views that he had expressed since before 1840 and even reaffirmed in the *Essay.* He considered the transmutation theory untrue to facts, unscientific in its method, and mischievous in its tendency. He continued to say that the volume made no impression on him and charged that the metaphysical contents could only be looked upon in scorn.

Agassiz was enough of a scientist that he could find the weak points of Darwin's work and he proceeded to pound them out. These were, of course, the jumps in the geological record, which still have not been filled in completely and probably never will, and the mechanism by which traits are passed on so that natural selection and the origin of variation can work. (Mendel's work was not published until 1900.) It would seem from the literature and from recent thought that Darwin won. However, during the 1860s in America, Agassiz was still revered so much that many simply dismissed Darwin's work completely.

Gray struggled onward in giving what he thought to be the true and equal battle for Darwin. Gray himself had one qualm about the theory and this concerned the absolute origin of life. With his long held religious view of a special creation, he set out to discover such a viewpoint in Darwin. In 1884 Gray wrote his *Darwiniana* which states in various ways that the *Origin* was not contrary to religious belief. This finally reconciled some of the churches to the theory. Previous to this book, its parts had been published in separate forms on many various occasions. Two of the better articles had even appeared anonymously in the *Atlantic Monthly,* carrying part of the battle to the laymen who missed the great debates before the professional scientists in the various scientific societies.

Agassiz considered Gray as an upstart who was trying to take his prestige away. He had never respected Gray very much, even from his first meeting with him in 1846, and he respected him even less now. Cordial relations were only interrupted once by Agassiz, who apologized to Gray, and the two appeared to be good friends even though the relationship was rather strained at times. Authorities of Agassiz think that he only apologized because his bad manners to Gray had hurt his own self-image of *the great professor.*

More time passed and neither man wavered in his determination or belief. Even as an old man, Agassiz, whose students eventually left him to support evolution, still could not put his great knowledge into generalizations more modern in approach. He kept faithful to his old education and a prioristic notions. Agassiz' work demonstrated immense amounts of careful, detailed observation; but, when facts had to be interpreted, Agassiz' generalizations were sweeping dogmatic affirmations that seemed to shut off further inquiry rather than to inspire fundamental questioning (Lurie 1960).

Mayr (1959) states that Agassiz' theory of a never-ending series of creations was far more in conflict with the Biblical account of creation than was Asa Gray's belief that God had created a universe endowed with the potency of evolving, a concept of evolution possessing Biblical dignity and grandeur. Agassiz, while professing to be religious, seemed to be less so than Gray on this point.

Agassiz had failed. Mayr describes him as follows: a great naturalist, the world's foremost authority on fossil fishes, a man of a stupendous breadth of knowledge, founder of one of the world's great natural history museums, embryologist—anatomist—systematist—paleontologist, predestined in every way, one would think, to welcome the unifying theory of evolution with open arms. Instead his great knowledge became entombed in dogma and idealism. He who could have been the true giant in zoology leading America in an understanding of Darwin's work ended up a slightly fanatical and somewhat bigoted man who failed to grow with his science (Packard 1898). His factual studies on glaciers and fossil fishes were among the best studies done, but in old age he illogically stopped short of obvious and natural conclusions and, unlike Lyell, Dana, and others, failed to adopt new ideas. He had closed his mind.

Gray on the other hand, while not doing so during his lifetime, certainly triumphed after his death; for as the years pass, with each new book being written about early American scientists, his name is increasingly mentioned and his fame grows. His hard work, perseverance, and open-minded approach to new paths in science, particularly toward plant physiology, led the way to modernization of botany and other sciences in America. His textbooks brought science to the everyday man, not in flowery speeches but in simplified scientific terms recognized the world over. His classification and naming of American plants assured the American people of an uncluttered and undisputed beginning of their botanical nomenclature. And his work with his own students produced new leaders with visions of things yet unexplored and questions yet to be asked.

Gray stood for the open-minded approach to science looking upon the domain of nature as essentially an open universe made for scientific investigation and interpretation. Agassiz stood for the closed-minded approach to science using his a priori hypothesis as his basis and suiting his experiences to fit it. When Agassiz died in 1873, fifteen years before Gray, he had already seen the effects of Darwinism and the changes in science. During the remainder of Gray's life, the old followers of Agassiz either changed their views or died, so that Gray was able to see the modernization of American philosophy in science and to realize that in part it was due to his own efforts. The first battle in the history of America's war over evolution had been fought.

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VIEWS OF INSTITUTE PARTICIPANTS ON ENVIRONMENTAL ISSUES

During the academic year 1972-73, the University of Wisconsin-Superior coordinated an in-service institute sponsored by NSF that was held on four campuses of the University of Wisconsin system. Using the Tilton project materials (Hershey et al. 1972) as a basic resource, the institutes focused on environmental issues, particularly those relating to water quality.

Most applicants identified the need to expand their knowledge about environmental issues and to learn how to plan laboratory studies in environmental science that could be utilized by their students. For many participants with inadequate subject matter backgrounds, the institute served to upgrade basic skills.

The institute faculty had considerable difficulty implementing this program. How does one enhance or encourage teachers to use materials and ideas developed in an institute? Based on the assumption that the teachers' incorporation of strategies relating to environmental science would depend upon their own views about environmental problems, an effort was made to measure their initial attitudes. At the end of the course of study, another response was sought to determine if there was any change.

The instrument used was that reported by D. R. Stronck in 1972, "A Questionnaire on Environmental Issues," *(ABT* 34[4]:212), which was originally developed by students. Its ready availability and timeliness overcame certain reservations regarding specific items. In addition, it allowed the comparison of responses of teacher participants to those of students and parents.

The specific questions found in Stronck's article will not be repeated here. For purposes of analysis, the response "I strongly agree" was arbitrarily assigned a value of 1. (Questions 6 and 15 were exceptions, and the responses were scored opposite to the others.) "Agreeing" was scored as 2, "Uncertainty" as 3, "Disagreeing" as 4, and "Strongly disagreeing" as 5. Since this is opposite of Stronck's method, the values in table 1 must be subtracted from 5 to be comparable to his data.

In addition to the attitude questionnaire, participants were asked to report certain characteristics of their background and experience. This information was used to determine if there was correlation between these characteristics and the views they expressed on the questionnaire.

The responses were coded on data cards, and all analyses were done by computer. Measures of partici-

Table 1. Significant correlation coefficients between participant characteristics and attitudes. Correlations of 0.205 are significant at the .05 level of probability for N = 95.

		Correlated with	
Item	*Characteristic*	*Item*	*Correlation*
1	Grade level assignment	7	0.227
		*12	0.347
		Sum	0.213
2	Total credit hours taken	1	0.252
3	Years teaching experience		
4	Sex		
5	Size of school		
6	Size of community		
7	Hours of environmental	8	0.256
	science teaching	12	0.236
		Sum	0.254

*Significant at the .001 level.