Helmholtz and the ideals of science and culture in Gilded Age America*

Helmholtz e os ideais de ciência e cultura na América dos Tempos Dourados

DAVID CAHAN

ABSTRACT: This paper presents Helmholtz's visit to the USA in 1893. That visit was the most celebrated of any scientist's to nineteenth-century America. If part of the explanation for the extraordinary reception that Helmholtz received when he visited the U.S. in 1893 rests with his distinguished scientific reputation, the other part, I'll argue, lies in the aspirations of his American hosts and the ways in which the ideals and values of science that Helmholtz represented found resonance in a rapidly developing American scientific scene. This story can illustrate my claim that American science in the Gilded Age (that is, from the mid-1870s to 1900) was far more robust than previous scholarship has allowed and that Helmholtz embodied ideals and values of pure as well as of applied science that many leaders of American science and culture hoped to see flourish in America.

RESUMO: Neste trabalho, analisa-se a visita de Helmholtz aos Estados Unidos, em 1893; uma visita que foi, mais celebrada que a de qualquer outro cientista na América do século XIX. Parte da explicação para a extraordinária recepção que Helmholtz teve nessa visita relaciona-se à sua destacada reputação científica. Eu argumento, entretanto, que a outra parte se relaciona às aspirações de seus anfitriões norte-americanos e ao modo pelo qual os ideais e valores da ciência que Helmholtz representava encontraram ressonância em um cenário norte-americano de rápido desenvolvimento científico. A análise desse episódio ilustra o meu argumento de que a ciência norte-americana na sua era áurea (isto é, de meados da década de 1870 a 1900) era muito mais robusta do que tem sido reconhecido até agora, e que Helmholtz incorporou ideais e valores tanto de ciência pura quanto de ciência aplicada que muitos líderes da ciência e da cultura nos Estados Unidos queriam ver florescer na América.

Introduction

During the late summer, early fall of 1893, the German scientist Hermann von Helmholtz visited the United States. He did so, on the official side, as head of the German delegation to the International Electrical Congress in Chicago, held in conjunction with the Columbian World's Exposition; on the unofficial side, his journey aimed to fulfill a long-standing personal desire to see America. The American

press and parts of the American academic community treated his sojourn with much fanfare. So too did elements of the American industrial, financial, and even political elites, who sought to make his acquaintance and proffer their friendship and hospitality. His visit, in fact, was the most celebrated of any scientist's to nineteenth-century America. Those of John Tyndall, William Thomson, T.H. Huxley, and Alfred Russel Wallace, for example, received considerably less public attention and private feting. Probably only the visits of Marie Curie and Albert Einstein in 1921 have been more celebrated.

My aim this morning is to try to explain the extraordinary reception that Helmholtz received. Part of the explanation is obvious enough: it rested on his distinguished scientific reputation. You may recall that during his long working career, from 1842 to 1894, Helmholtz was one of the premier physiologists and physicists, and that he also made seminal contributions to psychology, mathematics, chemistry, and meteorology. Furthermore, he invented an array of physical instruments – the ophthalmoscope and the resonator being the best known. On an institutional level, as professor of physiology at Heidelberg from 1858 to 1871, as professor of physics at Berlin from 1871 until his death in 1894, and as the founding director of the Physikalisch-Technische Reichsanstalt (the Imperial Institute of Physics and Technology) from 1887, he held three of the most important positions in German scientific life. While he devoted himself to pure science, his results also had important practical implications. His invention of the ophthalmoscope in 1851 proved to be a signal triumph in medicine, helping to show the practical value of physiology and physics for clinical medicine; his seminal musicological work, *On the Sensations of Tone as the Physiological Foundations of Music*, showed how science could help enrich the understanding of music; his highly successful popular lectures on science helped educate the public on the nature of science in general and on its recent, major results; and finally, his founding and leadership of the Reichsanstalt, an institution devoted to metrology and, more generally, to facilitating the mutual advancement of physics and industrial technology, meant that he was widely seen not only as some other-worldly academic scientist but also as someone who helped link science with industry.

These and other scientific achievements led to great reknown and celebrity for Helmholtz. He became an honorary member of numerous foreign scientific and medical societies. Virtually every educated person in Europe and beyond came to know his name. He met many of Europe's political leaders and social elite. He was an acquaintance if not friend of all the German Kaisers and Prussian Crown Princes of his day. During one of his many voyages to Britain, he met William Gladstone, the prime minister. When he came to the U.S., he met President Cleveland.

He was also acquainted with, if I may digress for a moment and give a final, apposite example of Helmholtz's many acquaintances among the political and social elite, Dom Pedro II. As this audience knows better than I do, Dom Pedro was a learned monarch who had great interest in contemporary science, technology, learning, and the arts. For both political and personal cultural reasons, you will recall, he made four long trips to Europe. During his trip to Europe in 1871, Dom Pedro toured the scientific facilities of the University of Berlin, where he probably first met Helmholtz. In 1876, Dom Pedro made an extensive, eight-week tour of the U.S. He visited Boston, where he toured scientific and cultural institutions, including Harvard, and met various scientists, including Alexander Graham Bell. He also spent two weeks at the Philadelphia Centennial Exhibition, devoting no less than four hours each day to studying the various exhibits devoted to industry and technology. There he saw Bell again, and met William Thomson (Lord Kelvin) as well. Thereafter Dom Pedro went to Europe, and in August he attended the opening of Richard Wagner's new *Festspiel* in Bayreuth. Kaiser Wilhelm I was there, as were the kings of Bavaria and Württemberg, many aristocratic figures, numerous musical personalities like Liszt, Saint-Saëns, Bruckner, and Tschaikovsky, and painters like Makart, Lenbach, and Anton von

Werner. Helmholtz too was at this historic cultural event. In April 1877, Dom Pedro again visited Berlin, and on his first day there he called upon Helmholtz, before going the next day to see Bismarck. Dom Pedro later sought to maintain his connection with Helmholtz by writing to him. Dom Pedro's cultivation of Helmholtz and other scientists, and his visits to American and European scientific and cultural institutions, were not only part of his personal learning process and his building of personal connections; he also hoped that these would one day somehow contribute to Brazil's emergence as a scientific, technological, industrial, and cultural nation on a par with those of Europe and with America. That was probably the general reason why he asked Helmholtz to send him the architectural plans of his Berlin physics institute.

Let me return to my main story, however. If part of the explanation for the extraordinary reception that Helmholtz received when he visited the U.S. in 1893 rests with his distinguished scientific reputation, the other part, I'll argue, lies in the aspirations of his American hosts and the ways in which the ideals and values of science that Helmholtz represented found resonance in a rapidly developing American scientific scene. This morning I'll use his visits to a series of cities – Chicago, Boston, Washington, and New York – to illustrate my claim that American science in the Gilded Age (that is, from the mid-1870s to 1900) was far more robust than previous scholarship has allowed and that Helmholtz embodied ideals and values of pure as well as of applied science that many leaders of American science and culture hoped to see flourish in America. I'll argue that American scientists and the American elite perceived him as an idol of science and culture, and that they manifested their idolatry through widespread and fulsome recognition, solicitousness, and praise of him.

Becoming Germany's Science Ambassador

With the end of the Civil War, American institutions of higher education and culture witnessed unprecedented expansion and reorientation. The extraordinary growth of the American economy from the 1870s until the mid-1890s and the desire of some Americans to enhance higher culture led to the founding of new higher-educational institutions as well as to the reinvigoration and expansion of older ones. Leaders of some traditional American colleges now began to consider the possibility of becoming universities offering graduate education and the Ph.D. degree. New institutions like Cornell, Johns Hopkins, Clark, and Chicago, and older ones like Harvard, Yale, and Columbia are prime, well-known examples of these developments, to which one might add the appearance of new institutes of technology, like MIT.

Helmholtz was well-known not only to American scientists and industrialists, but also to the cultural elite. He was a Foreign Honorary Member of the American Academy of Arts and Sciences, a member of the American Philosophical Society, and a Foreign Associate of the National Academy of Sciences. Prior to his trip of 1893, he had been invited no fewer than four times to lecture or participate in meetings in America. He refused all four invitations. In 1875, for example, Henry Dewey Noyes, the representative of the American Ophthalmological Society, asked him to come to New York City to attend the International Congress of Ophthalmology at the society's expense. He wrote:

> We do not ask you to come to witness our achievements in science: – it is not for us to speak in this matter; but we solicit your coming that American scientists may personally testify to you how warmly they appreciate your labors, and may exhibit their sense of indebtedness to your achievements. The Committee believe that you probably have

little conception of the enthusiasm with which your coming among us would be greeted. There is no voice among workers in science, which would be heard with more pleasure than your own.

Helmholtz's decisions not to accept these invitations suggest that in the 1870s and 1880s America lacked, for him, sufficient scientific importance to merit the long trip.

Then in the spring of 1893 the Reich government in effect ordered him to head the German delegation to the International Electrical Congress. As president of the Reichsanstalt it was his duty to go and to help bring definitive settlement to the international values of the fundamental electrical units and standards. He went with enthusiasm but also with foreboding of the dangers of American cities. He wrote his friend Hermann Knapp, a German-American ophthalmologist in New York City, that America "represents the real future of civilized humanity, while we in Europe see chaos or rule by the Russians approaching ever closer, and that it [the United States] includes a large number of the most interesting people".

On Official Business: The International Electrical Congress in Chicago

By 1890, Chicago stood only behind New York as the country's major commercial, financial, and cultural center. It had become, to borrow William Cronon's apt title, "nature's metropolis". The Second City was a work-in-progress: By the early 1890s, it was a heterogeneous mix of ethnic groups, and of a tiny, wealthy elite, a small middle-class, and hundreds of thousands of impoverished workers. Yet all suffered from the dismal state of its urban infrastructure and its high incidences of crime and vice. Its business and civic elites responded in part by bringing the Exposition, otherwise known as the White City, to Chicago to help clean it up and market its products to the world.

Yet the historical moment was not propitious. In May 1893, two months after Grover Cleveland assumed office, a financial panic struck the U.S. and the financial markets crashed. A monetary crisis led to many business failures and labor unrest, especially in Chicago. By the time Helmholtz arrived in late August calm had been restored, but the ensuing recession turned into a depression. It cast a pall over much of American life, while the fearsomely hot summer only added to the country's sense of woe. Helmholtz's presence, like the Exhibition and Congress themselves, brought a measure of relief to some.

Helmholtz's arrival was a publicly heralded event. *The Chicago Sunday Tribune* carried a story headlined "Helmholtz Arrives Tomorrow. Famous German Physicist and Electrician Will Speak at the Congress" and a picture of him. "No name is better known in the scientific world," it said, "and no man living has done greater work in solving perplexing scientific problems". *The Chicago Daily News* also announced his arrival and called him "one of the leading scientists of the world". It opined that, except for his height, he could have been mistaken for Bismarck. Its reporter found that age was beginning to show "on the great scientist, whose name has been known all over the world for more than a score of years".

Helmholtz served as the congress's honorary president, and so he formally opened it before hundreds of physicists and electrotechnologists from the U.S., Europe, and Japan. On stage with him were the delegates from ten governments. The newspapers reported with some drama the enthusiastic reception for him. One wrote:

> Scientists and philosophers are given too much to cold, speculative thinking that they are often set down as being incapable of manifesting greater enthusiasm. Those who think thus should have ... seen the reception accorded to Dr. von Helmholtz, the distinguished German scientist. When he was formally introduced dignity was forgotten and the audience rose en masse and waved hats and handkerchiefs.

Among those applauding that day were some of the dozens of American students who had studied physics with him in Berlin. *The Chicago Daily Tribune*'s front-page story carried the headline: "Homage to Genius. Electrical Congress Opens with Enthusiasm. Helmholtz Is Here. His Presence Creates a Deep Stir of Admiration". The *Tribune* said that "the nations of the earth, through their representatives, [were] paying homage to genius". The applause (temporarily) stopped after Helmholtz reached center stage and "bowed repeatedly" before his admirers. Yet this was but the beginning of his treatment as a demigod in the world of American science and beyond. The *Tribune* reported:

> Often during the afternoon the scientist was obliged to bow his acknowledgments to the audience, for every mention of the name of Helmholtz, every indirect reference to him even, was greeted with a hearty burst of applause. When he was introduced as honorary President to make a speech he received such an honor as is seldom accorded to any man.

Thomas Corwin Mendenhall, a physicist who from 1889 to 1894 headed the U.S. Coast and Geodetic Survey and who chaired the committee on the congress's organization, proclaimed that it was not possible for the congress to honor Helmholtz; rather, its election of Helmholtz as honorary president was an honor to the congress.

During the next four days the congress definitively settled on the units and standards of electrical resistance, current, electromotive force, quantity, capacity, work, power, and induction. Afterwards, the American electricians hosted a banquet for their foreign colleagues. The group proclaimed Helmholtz "'the Father of Electricity'", an emotional proclamation that, if not meaningless in itself, at least flew in the face of 300 years of electrical science and technology. Indeed, one newspaper claimed that the real "lion of the occasion" that evening was not Helmholtz but Thomas Edison. An anecdote told by a German scientist present in Chicago points in a similar direction. While a group of individuals was standing around talking, a new person joined them and immediately all eyes fell upon him. A reporter standing nearby asked: "'Who is it?' – 'That is Helmholtz.' – 'Who is Helmholtz?' – 'The famous physicist (etc.)'. 'Oh, I understand'", said the reporter, "Edison in a small way".

At the banquet's headtable that final night sat Elisha Gray, the Chicago inventor and electrotechnologist, Helmholtz, and several other foreign leaders. Gray asked Helmholtz to speak, and the latter declared:

> We Europeans have come over here with the feeling of a good father rejoicing in the success of his children, to which he himself could not attain. Europe is too narrow for the splendid march of electrical progress and America has grandly performed the task set before it. We see in you the result of better conditions and prospects than we have enjoyed, and we rejoice with you in your remarkable advancement. Gentlemen, I drink my glass to the great American Nation.

His audience cheered and emptied their glasses to his flattering and diplomatically skillful toast that treated American science and technology as if it were the peer of Europe's.

The congress marked a turning point in electrical metrology generally and constituted a heady moment in American science and technology in that the American participants were treated as the full peers of their foreign colleagues. If nothing else, it had brought together the largest, most-important set of physicists and practical electro technologists who had gathered to date on American soil. The

mixture of academic physicists and practical electro technologists demonstrated positive, close working relations between science and technology.

With the congress concluded, Helmholtz spent much of his final six days in Chicago visiting the Exposition, which reportedly much impressed him. He doubtless visited the large Electricity Building. Probably, too, he visited the German Fine Arts exhibit, where Ludwig Knaus's portrait of him, which normally hung in the National Gallery of Berlin, was on display. Finally, he may also have visited the nearby, newly founded University of Chicago. The entire university, including its Ryerson Physical Laboratory, was then under construction, and its new professor of physics, Albert A. Michelson, who had worked as a "postdoc" in Helmholtz's Berlin laboratory in 1880-81, had himself just arrived in town. The university, which among other things intended to be a German-style, research institution, would of course soon become one of Chicago's leading cultural ornaments.

Harvard and Boston

Following a two-week trip to the Far West, Helmholtz undertook a three-week sojourn on the East Coast in good part to see its scientific institutes and universities. He first visited Boston and Cambridge, just as Dom Pedro had done seventeen years previously. It may be a measure of Harvard's earlier standing in the world of science that in 1871 Helmholtz referred to it as "the University of Cambridge, in the United States". But now, in 1893, he thought it worth a personal visit. A group of Harvard professors led him on a day-long tour of the campus, including its laboratories, which meant that he doubtless saw, among other things, two key scientific buildings: the Jefferson Physical Laboratory and the Museum of Comparative Zoology.

Helmholtz had several excellent personal connections in Cambridge and Boston that helped make his visit especially fruitful. One was Henry Pickering Bowditch, the Harvard physiologist who had studied with him in Heidelberg in the late 1860s. As Dean of the Harvard Medical School, he showed Helmholtz around its facilities. Helmholtz may have also visited the nearby Massachusetts Institute of Technology and the Boston Society of Natural History, which, like the medical school, were then all located on Copley Square in Boston.

Another important Harvard connection was the psychologist Hugo Münsterberg, who had studied physiology at Leipzig in the early 1880s with Helmholtz's close friend Carl Ludwig as well as experimental psychology with Helmholtz's former assistant Wilhelm Wundt. In 1892, William James arranged for Münsterberg to come to Harvard and lead its Psychological Laboratory. Münsterberg attended the Exposition in Chicago, where he saw Helmholtz; that September, Helmholtz visited him in his Harvard laboratory. At Harvard, Münsterberg's set included the philosophers Josiah Royce, George Santayana, and George Herbert Palmer, as well as James and Bowditch.

Yet a third Harvard connection and meeting came with James, who had heard Helmholtz lecture once in Heidelberg and twice in Berlin. Though James disagreed with Helmholtz's epistemological views and though he thought him a very poor lecturer, he otherwise idolized him. At various times he spoke of him as "perhaps the first scientific genius now above ground", as being "probably the greatest scientific genius extant", as "the immortal Helmholtz". He invited him to his New Hampshire cottage for an afternoon. He wrote his brother, Henry, that "the great Helmholtz" was

> […] the most monumental example of benign calm and speechlessness that I ever saw. He is growing old, and somewhat weary, I think, and makes no effort beyond that of smiling and inclining his head to remarks that are made. At least he made no response to remarks of mine; but Royce, Charles Norton [the Harvard art historian and editor], John Fiske, and Dr. [Henry Pickering] Walcott, who surrounded him at a little table where he sat with tea and beer, said that he spoke. Such power of calm is a great possession.

All in all, James judged Helmholtz to be *a herrlicher Mensch*. Helmholtz's visit to Harvard suggests solid academic ties between himself and its leading figures.

Washington and Johns Hopkins

Following brief visits to Yale and Princeton, Helmholtz next spent about a week in Washington, including a day-visit to Baltimore. There was an especially strong scientific community in Washington in the late-nineteenth century, and Mendenhall introduced Helmholtz to its leading figures. He arranged meetings with a group that included Samuel Pierpont Langley, the astronomer, physicist, and secretary of the Smithsonian; Simon Newcomb, the mathematical astronomer and superintendent of the Nautical Almanac Office; and John Shaw Billings, the army surgeon and librarian, and designer of the new Johns Hopkins University Medical School. He informed Helmholtz that the Cosmos Club –"composed mostly of gentlemen engaged in Scientific work" – was located across from his hotel. (The Cosmos Club, incidentally, derived its name from Alexander von Humboldt's widely popular and encyclopedic *Kosmos*, and was the principal meeting place and social center for scientists in Washington.) These and other local scientific notables would be waiting for Helmholtz at the club on the evening of his arrival, Mendenhall promised. He also wanted Helmholtz to visit the Coast and Geodetic Survey.

Whereas Mendenhall introduced and chaperoned Helmholtz around scientific Washington, Henry Villard, the German-American financier, journalist, and politico did so around political Washington. Villard had been an important figure both in Cleveland's securing the Democratic nomination in 1892 and in his successful presidential campaign. He arranged for Helmholtz to visit President Cleveland one afternoon. Helmholtz also met a series of Congressional senators and representatives (and witnessed a session of Congress). In Baltimore, Daniel Coit Gilman, the president of the Johns Hopkins University, escorted Helmholtz around campus.

New York: Steinway, Columbia, and Long-Distance Telephony

Helmholtz spent his final days in America visiting New York City (again). He first visited the Steinway piano factory and Steinway Hall. This visit did not occur by chance: The firm and Helmholtz had a long-standing, mutually beneficial relationship that reached back to the 1870s. Steinway said the firm benefited from applying Helmholtz's acoustical theories in developing its duplex scale, and it certainly benefited from using his resonators to check frequencies and, more generally, listen to sounds. Moreover, it also benefited by obtaining letters of endorsement from him attesting to the high quality of Steinway pianos, letters which it then published as de facto advertisements. In turn, Helmholtz received a grand piano as a more or less permanent loan from the firm.

In New York, Helmholtz examined Steinway pianos at both the factory and the concert hall; he

was especially interested in seeing whether the manufacturing composition and procedures agreed with his own acoustical studies. At the factory, the entire staff gathered round to meet him. Steinway insisted that Helmholtz choose a new piano. (The firm later sent him a new grand piano, which led him again to endorse Steinway pianos.) Then Helmholtz went to visit Steinway Hall. The firm cultivated its relationship with him for commercial advantage, and Helmholtz obliged gladly and profited from it.

Helmholtz devoted the better part of the next three days to visiting Columbia College, including with its president, senior faculty members, and supporters. Both Columbia and the city in general were, like Chicago, very much in rapid transition. The city was not only expanding its physical infrastructure and economy, it was also becoming an international cultural center. As for Columbia, under the leadership of Seth Low and others it transformed itself during the 1890s from a provincial college into a research university that sought national and even international standing. Among the leaders in this transformation were two former Helmholtz students from the University of Berlin: Nicholas Murray Butler, the philosopher and educator, and John Burgess, the political scientist. Both had been much impressed by German science and scholarship, including the organization of German universities; the University of Berlin showed them what a research-oriented university with outstanding faculty might be like. Other leading faculty members who had studied or gotten their Ph.D.s in Germany, and who helped transform Columbia, included the physicist Ogden Rood, the economist Edwin R.A. Seligman, the historian Herbert Levi Osgood, the psychologist James McKeen Cattell, and, later, the anthropologist Franz Boas.

Starting in 1890, Low raised fresh money – and was himself one of Columbia's major financial benefactors – to purchase land in Morningside Heights and to construct an entirely new campus there. In 1896, four years after the purchase, Columbia College moved its campus from its inadequate, cramped buildings in midtown, and formally became Columbia University in the City of New York.

It was within this historic context of a transforming Columbia that Helmholtz visited and gave two talks there. The first was to the College of Physicians & Surgeons, where he spoke before a packed audience of ophthalmologists as well as other medical doctors and medical students on the history of his invention of the ophthalmoscope. His message was simple: He, rather than several of his highly able predecessors and contemporaries, had invented the ophthalmoscope only because "[t]hey had stopped in the middle of their way instead of going on to the end". The only original thing he had done, he said, was "to ask how the optic images could be produced by the light coming back from the illuminated eye. All my predecessors had failed to put this question to themselves. They had stopped in the middle of their way instead of going on to the end". He thus admonished his listeners "to go to the end when investigating natural phenomena", though he never specified how one knew when one was there.

That evening, the Helmholtzes dined with the Lows in their Upper East Side home. After dinner, the two couples repaired to Columbia's Law Library, where Low had invited more than 500 of New York's finest to a reception to meet Helmholtz. The guest list naturally included Helmholtz's friends and other leading colleagues on Columbia's faculty as well as the deans of Columbia's faculties. Edison was there too, just as he had been in Chicago. So too was the philosopher and mathematician Charles Sanders Peirce, who came to New York just to meet and hear Helmholtz. And so too were leading literary figures, editors, and publishers. Moreover, many of Columbia's major benefactors and trustees came to meet Helmholtz: for example, J. Pierpont Morgan. So, too, did politicians like Abram S. Hewitt (the industrialist who founded the Union for the Advancement of Science and Art [later Cooper Union], U.S. congressman, and former mayor of New York [1886-88]), Mayor Thomas F. Gilroy (1892-94), and Elihu Root (statesman and future secretary of war and of state, U.S. senator from New York, and Nobel

Peace Prize winner). Leading New York professionals also came, like the well-known architects Richard Morris Hunt and Charles T. McKim; major clergymen, Bishop Henry Codman Potter (rector of Grace Church and bishop of the diocese of New York) and the Reverend Dr. Morgan Dix (rector of Trinity Church), and lots of powerful attorneys and financial figures. Many were from old Knickerbocker families, many were philanthropists, and a number of them were trustees of New York's leading cultural and social institutions, not least Columbia itself. By inviting these and other professors, politicians, financiers, businessmen, literary and professional figures, Low was giving them an opportunity to meet the German *Meister* and so to enhance their and the city's sense of being in contact with European high culture. By the same token, he was naturally also reinforcing their bond with Columbia and their confidence in the institution. Since Low was in the midst of a fundraising campaign to finance Columbia's new campus, the reception also became, if only in effect, a Columbia fundraiser. What better sign that Columbia was on its way to becoming a modern university than to have such an event graced by Helmholtz? Low pronounced the evening "brilliant". The *New York Times*, reporting on the event, informed its readers that "Prof. Helmholtz is admired wherever science has a friend".

Helmholtz gave his second talk the next day in Columbia College's Law library. It too was jampacked – some 600 to 800 students and faculty, as well as outsiders like the physicist J. Willard Gibbs and the paleontologist Othniel Marsh, both of whom came down from Yale, Peirce, Steinway, and Alexander Graham Bell, who came down from Halifax. Low introduced Helmholtz as being "without a peer in scientific circles since Darwin's death". He asked Helmholtz to address Columbia's students, and Helmholtz did so with a lecture on the acquisition of knowledge and "the sciences in general". Though Helmholtz's handwritten notes suggest that he had probably composed it rapidly while in New York, his theme and viewpoints represented essentially those that he had been championing for decades.

He said that science in its early phase was an activity devoted simply to collecting diverse bits of knowledge. The principal difference between the scientific collection of knowledge and that accumulated by laypersons on a daily basis in ordinary life, however, was that the former was intentional in nature. He argued, furthermore, that scientists seek to make their accumulated knowledge as complete as possible, and to preserve it so as to retrieve and use it at will and forever. Such an accumulation and recombination of knowledge over many generations constituted, he said, the "principal cause of the superiority of mankind over all other living creatures". He maintained, however, that science was not merely "a bare enumeration of facts and data". For it also concerned "the causal connection of the facts". Predictions about future action, be it those about humans or inert matter, required more than merely stating the facts. Knowledge of future human actions, he declared, requires probabilistic knowledge about human intentions. Hence: "Every voluntary action may be considered as an experiment, the success of which we believe to know, before we let it begin". Yet science's ability to predict was dependent on "the laws of nature, which regulate all changes of real objects". "All the miracles of modern industry", he claimed, "are based on this possibility, and I need not to expose in detail to You, who live amongst these wonderful performances of modern industry, how much power man has gained of natural forces under his will by the results of Science". The message of technology's dependence on science could not have been clearer.

Yet Helmholtz also acknowledged that to a certain extent intuition sometimes had to serve in lieu of as-yet-unknown laws. Indeed, "in the present state of imperfect scientific development", Helmholtz explained to Columbia's students, "we are reduced to a mixture of both [i.e., intuition and laws], and have to strive to a completion and perfection of Science". But he warned that using intuition carried a

danger, one that had plagued science since the time of the ancient natural philosophers. Those who misused or abused intuition in science were erroneously led into believing that knowledge of human understanding alone or analysis of "the fundamental faculties of our own mind" without observational experience could lead to the laws of nature. Here was his old intellectual nemesis that he variously described as idealism, the identity philosophy, Hegelianism, or some combination of non-empirical science. This philosophical outlook had "retarded" scientific development, he warned. The students received his lecture, Rood said, "amid the wildest enthusiasm".

Bell had invited Helmholtz to accompany him at the conclusion of his talk to see the American Telephone and Telegraph Company's central telephone station downtown and to experience a long-distance telephone call. Bell had long greatly admired Helmholtz; during the 1860s, he had studied and been inspired by Helmholtz's work on physiological acoustics, and reportedly "explained that, without Helmholtz's researches in the field of sound, he could never have invented the telephone". Helmholtz, for his part, was keen to experience long-distance telephony. In the presence of a bevy of reporters, top company officials placed long-distance calls from New York City to Boston, Chicago, and Washington, and Helmholtz had conversations with individuals in all three cities. Afterwards he inspected the remainder of the station, dined at Low's home again, and then participated in another reception held in his honor, this one at and by the Century Club, one of New York's most exclusive and highly prestigious literary men's clubs, where, among other things, writers and artists met with potential benefactors. His visit there is an indication of the extraordinary treatment he received from New York's cultural elite.

Finally, as part of his visit to Columbia, Helmholtz also went to see one of his former students, Michael Pupin, the physicist and electrical engineer who was now a faculty member at Columbia. Pupin referred to Helmholtz as "my greatly revered teacher". He claimed that it was the "great Helmholtz" who, through his scientific leadership and mentoring, stood behind such epochal work as Heinrich Hertz's experimental proof of Maxwell's electromagnetic theory, Guglielmo Marconi's application of Maxwell's theory in developing wireless telephony (and then radio), and Wilhelm Conrad Röntgen's discovery of X-rays. Helmholtz visited Pupin's laboratory. Pupin was then in the process of inventing a method of electrical tuning resonators (i.e., like the "modern" form of adjusting a knob on a radio to receive the desired frequency). Resonators had long been intimately associated with Helmholtz's name. Pupin showed him his electrical resonators and his research with them. The electrical resonator was used for selectively detecting alternating currents at definite frequencies, which made it useful for harmonic telegraphy. Helmholtz "was quite impressed", Pupin said: Helmholtz found Pupin's electrical method to be better than his own acoustical method. Pupin would go on to become a leading physicist and electrical engineer, and he maintained throughout his long, distinguished career that his various achievements in electrical-engineering matters rested on the solid scientific basis that he had acquired under Helmholtz's tutelage in Berlin.

Conclusion

By any measure, both the official and the unofficial portions of Helmholtz's visit to America had been a great success. In Chicago, Boston, Washington, and New York he had been, as Mendenhall

rightly judged,"made the lion of the hour". Mendenhall noted that throughout America,"in all centers of culture", Helmholtz was received"as a prince of science".

The elite in Gilded Age America, let me suggest by way of conclusion, perceived at least three aspects of Helmholtz's work and person that resonated with their own ideals and values of science and culture, and that led them to fete and idolize him. They saw him as someone who upheld, practiced and altogether embodied a vision of science for its own sake, for the search after"the laws of nature". The continued spread and deepening of that ethos in America was needed, many believed, if American university professors were to do world-class scientific research. Second, and at the same time, they saw in Helmholtz's scientific efforts and career a belief in the intimate relationship between science and technology. There was a widespread conviction, then if not now, that advanced technology depended on science. Helmholtz's own inventions as well as his leadership of the Reichsanstalt; the dependency of Bell's telephones, Steinway's pianos, and Pupin's resonators on his prior scientific results; and the general development of electrical metrology–all these served to prove or at least reinforce this conviction. Third and finally, the American elites perceived in Helmholtz – in his accomplishments, his person, and his persona – that the advancement of science and technology ipso facto meant the advancement of culture and America's international standing. Gilded Age America was nothing if not materialistic; its greatest benefactors were also its greatest beneficiaries in commerce and industry. Efforts to create universal standards in science and technology, like those at Chicago, meant that the new, developing world of America was becoming more or less an equal partner in the spread of global scientific and technological culture, while efforts to create world-class research universities like Chicago, Harvard, Hopkins, and Columbia meant that the American elites recognized that adopting and adapting the German model of institutions of higher education was one key to spreading and deepening culture in America. In sum, the American elites saw in Helmholtz the ideals and the values that many hoped to realize in America in the future. He was the great *Kulturträger*, the great bearer of culture, not only for many Germans but also for many Americans. Their heroizing and idolatry of him was not without reason.

*Palestra apresentada no X Seminário Nacional de História da Ciência e da Tecnologia, Belo Horizonte (2005).

e-mail do autor: dcahan@ulnotes.unl.edu

Artigo recebido para publicação em 11/2005. Aprovado para publicação em 03/2006.